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AN ACCOUNT  
OF  
LORD BACON'S  
NOVUM ORGANON SCIENTIARUM;  
OR,  
NEW METHOD OF STUDYING  
THE SCIENCES.

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*THE FIRST, OR INTRODUCTORY PART.*

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Sir Francis Bacon, Lord Verulam, is justly held the founder of *Experimental Philosophy*. He proposed his plan in his *Instauratio Magna*, with so much strength of argument, and so just a zeal, as renders that admirable work the delight of all who have a taste for solid learning.—MACLAURIN'S *Account of NEWTON'S Philosophical Discoveries*.

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## ACCOUNT

OF THE

# NOVUM ORGANON.

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HOMO, NATURÆ MINISTER ET INTERPRES, TANTUM FACIT ET INTELLIGIT  
QUANTUM DE NATURÆ ORDINE RE VEL MENTE OBSERVAVERIT; NEC  
AMPLIUS SCIT, AUT POTEST.—*Nov. Org.*

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LORD BACON was the first who taught the proper method of studying the sciences: that is, he pointed out the way in which we should begin and carry on our pursuit of knowledge, in order to arrive at *truth*. He gave a set of rules by which mankind might deliver themselves from slavery to names, and from wandering among fanciful systems, and return once more, as little children, to the school of nature. The task he chose was far more useful to the world, and honourable to himself, than that of being, like Plato or Aristotle, the author of a new sect: he undertook to expose the errors of those who had gone before him, and to shew the best way of avoiding them for the future: he had the principal share in pulling down the old building of a false philosophy, and, with the skill of a superior architect, he laid the foundation, and sketched the plan of another fabric; and gave masterly directions to those who should come after him—how, upon the ruins of the first, the temple of science must be erected anew. As, in a great army, there are some whose office it is to construct bridges, to cut paths along mountains, and to remove various impediments, so Lord Bacon may be said to have cleared the way to knowledge; to have marked out the road to truth; and to have left future travellers little else to do than follow his instructions: he was the miner and sapper of philosophy, the pioneer of nature; and he eminently promoted the dominion of man over the material world. He was the priest of nature's mysteries; and he taught men in what manner they might discover her profoundest secrets, and interpret those laws which nature has received from the great Author of all.

It is the object of this Treatise to make our readers acquainted with Lord Bacon's Philosophy, as it is contained in his great work, the *Novum Organum*; in which we find the principles of that improved

method of conducting the inquiries of science, which has now so long and so happily prevailed. To accomplish this design with the more effect, it will be desirable, first, to draw their attention, in a few words, to the state in which Bacon found the world, as to knowledge and science, at the time when he flourished. For, as the returning light appears more glorious after the sun has been eclipsed—and the order and beauty of nature would look doubly striking to an eye that had seen that chaos from which she first arose, when all was without form and void,—so, if we glance, but for a moment, at that darkness which so long overshadowed the human mind, and gave birth to so many phantoms and prodigies, under the name of science, this retrospect will serve to show more clearly the merits of a philosopher, who may be regarded as the morning star of that illustrious day which has since broken out upon mankind; and in the spirit of whose method, even the immortal NEWTON himself explored the heavens—by the aid of a sublime geometry, as with the rod of an enchanter, dashed in pieces all the *cycles, epicycles, and crystal orbs* of a visionary antiquity; and established the true Copernican doctrine of astronomy on the solid basis of a most rigid and infallible demonstration.

✓ In several of the fine arts, in which chiefly the taste and imagination are concerned, such as poetry, rhetoric, statuary, and architecture, the ancients, according to general opinion, have equalled, if not surpassed, any of the moderns. Homer and Demosthenes continue, notwithstanding the flux of time, to retain their station as the masters of eloquence and song; and those exquisite statues, the Venus and the Apollo, still command our admiration as perfect models of what is chaste, and severe, and beautiful in the art of sculpture. The ancients nobly distinguished themselves also in those more rigorous exercises of the understanding which are demanded by pure mathematics; in proof of which it is sufficient to quote the name of Euclid, and of Archimedes whose discoveries in geometry and mixed science entitle him to be regarded as the *Newton* of all antiquity; but it was reserved for the moderns to invent a *calculus*—a new and more profound arithmetic, which was called for by a more exact acquaintance with nature herself, and was to be applied to that more improved state of natural science which is peculiar to later times: we allude to the doctrine of *fluxions*, or the *differential* method of Newton and Leibnitz; since cultivated, and applied to physical astronomy with great success by the French, and especially by LA PLACE. In most of those branches of knowledge, however, which rest on the basis of *experiment* and *observation*, the ancients almost entirely failed. The case is, that to form *theories*, or systems of science and philosophy, from a hasty view of facts and appearances, is an easy task, since this can be done without the labour of close and patient thinking: and if antiquity be, in truth, as Bacon himself represents it, but the childhood and youth of the world, it is nothing more than we might expect that, at that period of its existence, imagination should prevail over reason; and that the calmer and more successful exercises of the latter should not unfold themselves till a maturer age.

One instance, out of many, in natural science, may suffice to convince the reader to what absurd and extravagant notions the

mind can reconcile itself, when once permitted to rove into the regions of imagination, unrestrained by that strict and scientific method, so successfully pointed out by Lord Bacon, and which it is our present object to explain. *Cosmas Indopleustes*, who lived so late as the *sixth century*, affirmed that the earth was an oblong plane, surrounded by an impassable ocean; an immense mountain in the form of a cone, or sugar-loaf, placed in the north, was the centre around which the sun, moon, and stars daily revolved: the shape of this mountain, and the slanting motion of the sun, accounted for the variable length of the days, and the changes of the seasons. The heavens were supposed to be an immense arch, one side of which rested on the earth, and the other on two mighty pillars beyond the sea; under this vault a multitude of angelic beings were employed in guiding the motions of the stars. Such was the theory which gravely presented itself for adoption, seven or eight centuries later in the world than Euclid, Archimedes, and Apollonius!

Abundant instances of almost equal absurdity might be collected from the opinions of the ancients, on various other branches of science. Take, for example, the doctrine of *sensation*, or feeling, in what was called the *Peripatetic* school, so called from a word signifying to *walk about*, because it was customary for the disciples to study and dispute as they walked in the *Lycæum*, a place at Athens which was appropriated to their use. Of this school, the founder was ARISTOTLE, a man of immense genius, who obtained the greatest popularity, and the most extensive influence over the opinions of mankind, of all the philosophers of antiquity, and who held the minds of men in a kind of intellectual bondage for about two thousand years. In the Peripatetic philosophy, what takes place in *sensation* was thus described: a sort of images, or, as they were termed, *sensible species*, that is, certain films of the shape of bodies, came off, it was said, from the objects of sense, and arriving at the organs which were proper to them, were admitted to the nerves, and by them conveyed to the brain: here these images were impressed, as the engraving of a seal on wax, and being now refined into what were called *intellectual species*, the whole business of sensation and perception was supposed to be accounted for. Thus by a jargon of words were men taught to believe they understood the manner in which *matter* communicates with *mind* or *spirit*, and their operation upon each other, which, all that has ever been said or written on the subject, shows to be inexplicable, and to be received simply as a *fact* in the constitution of sentient being.

Up to the time of Lord Bacon, Aristotle still maintained, in a very great degree, his dominion in the realms of philosophy—a dominion which, at some periods, had been scarcely less absolute over the minds of men, and far wider and more lasting than ever his renowned pupil Alexander was able to secure over their bodies. Possessed of a most acute and penetrating mind, and a singular talent for minute investigations, he was qualified, in this respect, for philosophical inquiries far more than ordinary men. His writings in natural history in particular, constitute a mass of physical and anatomical facts, which must have resulted from a course of very diligent observations. Neglecting, however, that rigid and exact practical method which is essential

to all natural science, too much devoted to subtil distinctions of words; and too ambitious of gaining an ascendancy over the opinions of mankind, he pronounced too boldly on nature's operations, and spent his energies too often in useless or obscure questions. In his desire to set up his own dogmas, in opposition to ancient opinions, he is sometimes guilty of misrepresenting the philosophers of a remoter antiquity; and he frequently veils himself in an obscure and unintelligible jargon. Lord Bacon describes his propensity to tyrannize over men's minds, by saying that, "as though he had been of the race of the Ottomans, he thought he could not reign securely unless all his brethren were slain." Cicero, who seems to have had some respect for Aristotle's philosophy, acknowledges that, in his time, it was understood by very few even of the philosophers themselves. His *Logic*, which is peculiarly his own, is undoubtedly a great effort of human ingenuity; it consists in an *analysis* of that process of the mind which, however rapid, and almost imperceptible, must take place in all sound and correct reasoning. It furnishes the model to which all such reasoning may be reduced, and serves as a test by which the justice of an argument may be tried, if it be ever necessary thus minutely to put down all the steps by which the conclusion is arrived at. In the discoveries of science it can of course afford little or no assistance, and it was the mistaken attempt to employ it for this purpose, that so long excluded the proper method of entering on philosophical researches, and filled the minds of men with mere words, and confused notions. Bacon's observations on this subject in his *Advancement of Learning*, show that his frequent condemnations of the logical philosophers were levelled against the extravagant perversions of Aristotle's *Dialectics*, with which these schoolmen were chargeable, and to which Aristotle himself had led the way. His logic was the engine by which, for ages, the minds of men were bewitched in a manner that was altogether extraordinary, and diverted from things themselves to mere words.

The philosophy of Aristotle, which it would be foreign to the purpose of this treatise more than to characterize generally, without entering into its details, obtained the same credit at Rome, under the Cæsars, which it had already acquired in Greece; being patronized by both Julius and Augustus. Towards the close of the fifth century, the influence of Aristotle began to prevail over that of Plato in the Christian world. After considerably declining during the sixth century, it again revived; and in another century it had gained such an ascendancy that Aristotle seems to have been every where triumphant. Glosses, paraphrases, summaries, arguments, and dissertations on his works were composed without end; as if to make "darkness visible." Many of the inhabitants of the west learned Arabic in order to read a translation of them in that language. The Latin tongue was made another medium of their circulation, and they were read in most parts of the known world. Men were every where taught to believe in *matter*, *form*, and *privation*, as the origin of all things; that the heavens were self-existent, incorruptible, and unchangeable; and that all the stars were whirled round the earth in solid orbs! Aristotle's works were the great text-book of knowledge, and his logic was the only weapon of

truth. Men's minds, instead of simply studying nature, were in an endless ferment about occult qualities and imaginary essences; little was talked of but *intention* and *remission*, *proportion* and *degree*, *infinity*, *formality*, *quiddity*, *individuality*, and innumerable other abstract notions. The Latin tongue, which was employed by these scholastics, was converted into a barbarous jargon, which a Roman would not have understood; and, in the end, the most sectarian bitterness was produced, sometimes ending in bloody contests. In the midst of these disputes, Aristotle was still the grand authority. Christians, Jews, and Mahometans, united in professing assent to the great lawgiver of human opinions: not Europe alone, but also Africa and Asia acknowledged his dominion; and while his Greek originals were studied at Paris, translations were read in Persia and at Samarcand.

The rage for disputation which now began to prevail in consequence of the spread of this philosophy, induced the council of Lateran, under Pope Innocent III., to proclaim a prohibition of the use of the physics and metaphysics of Aristotle; but awful as were then the thunders of the Vatican, they were not mighty enough to dethrone him from that despotism over men's minds, which, by long custom, had now rendered itself almost omnipotent. The passion for the Aristotelian subtilties had become so general, that, notwithstanding Pope Innocent's decree, it was soon found necessary to favour publicly, in some degree, at least, the study of their author; and accordingly, his *Dialectics*, *Physics*, and *Metaphysics* were received into the University of Paris by an express statute to that effect. In England his doctrines were cherished with as great an eagerness as elsewhere. From about the end of the twelfth century the very name of Aristotle operated like a charm; his writings had obtained universal circulation, and in some of the universities of Europe statutes were framed which required the professors to promise, on oath, that in their public lectures on philosophy they would follow no other guide!

From this period till the close of the sixteenth century, though the authority of Aristotle still continued in the schools, the minds of men were gradually preparing to shake off his yoke, and a more propitious era was fast approaching. The revival of learning in the fifteenth century, the invention of the art of printing, and the Reformation, had done much to prepare the world for that new light which was afterwards to be cast over the fields of science, hitherto covered with darkness, and peopled only with airy and delusive phantoms. A few distinguished men—as *John of Salisbury*, *Gros-lête*, Bishop of Lincoln, *Roger Bacon*, *Ludovicus Vives*, and others, had taught mankind that neither the decrees of the Vatican, nor those of the Grecian schools, were incapable of being resisted. *Gilbert* had successfully investigated the laws of magnetic attraction, and furnished an excellent specimen of reasoning from experiment. In opposition to the system that was held by Aristotle and his followers, which made the earth the centre of the universe, *Copernicus* had revived the ancient Pythagorean doctrine of the earth's motion round the sun, and had discovered the true theory of the planets. *Galileo*, *Kepler*, *Gassendi*, and others who lived at the same time with Bacon, were acquiring a well-earned fame by their improvements in geometry and physics; and the whole world of science

already sighed to be redeemed from the darkness of the middle ages, and the bondage of the schools. *Martin Luther*, who had been taught the philosophy of Aristotle in his youth, had expressed his contempt for its vanities, and rejected it with indignation. *Ramus*, also, had attacked the existing opinions at Paris, and disputed publicly against Aristotle's doctrines in the university of that city. Like many other honest followers of truth, however, in this wretched world, which has always loved darkness rather than light, he suffered severely for his boldness. As a punishment for his presuming to question the infallibility of the great despot of all knowledge, in an edict of the French parliament, under Francis I., the said Peter Ramus is gravely pronounced to be "insolent, impudent, and a liar;" his books are, now, and for all time coming, condemned, suppressed, and abolished, and the author is solemnly prohibited from copying, or even reading, his own works. *Bruno*, *Campanella*, *Patricius*, *Nizolius*, and some others, also contributed their part to undermine the influence of Aristotle.

It was reserved, however, for Francis Bacon, Lord Verulam, to break the spell of the mighty enchanter of Stagira, and to give a final blow to the scholastic philosophy;—to make one grand and general attempt to deliver men's minds from the bondage of two thousand years;—to assert the right of that reason with which the beneficent Creator has endowed man, as above all authority merely human;—and to sketch the outline of one grand and comprehensive plan, that should include in it the endless varieties of our knowledge, and guide our inquiries in every branch. Born in the year 1561, and early entered as a student at Trinity College, Cambridge, this great genius soon began to feel dissatisfied with the vagueness and uncertainty of the existing state of knowledge, the want of connexion between the sciences and the arts, and the consequent uselessness of the reigning speculations as regarded the purposes of life. The more he thought on the subject, the more he was convinced of the vanity of the scholastic learning of the times, and of the necessity of a thorough reformation in the method of treating the knowledge of nature, by laying aside all conclusions not founded on observation and experiment. He saw plainly that a great part of the evil lay in the extensive influence which Aristotle still possessed in the schools; that *nature* and *fact* were neglected for the study of his doctrines, which were the arbiters in all disputes; the properties of matter, and the laws of motion, by which all effects are produced, were lost in useless distinctions and dry definitions; the powers of the mind were exhausted in grave trifling and solemn folly; and the real advancement of human knowledge was altogether hopeless, so long as such a state of things prevailed. A century or two earlier, the contests about *names*, and *forms*, and *essences*, were sometimes more serious than a mere strife of tongues: they ended in actual bloodshed; while the disputants took the side either of *Occam*, "*the most subtil*," or *Duns Scotus*, "*the invincible*," the famous champions of the day; and if the din of this philosophical, or rather unphilosophical war now raged no longer,—if those imposing titles were not now heard which had formerly been bestowed on the leaders of rival parties, such as the *most profound*, the *marvellous*, the *perspicuous*, the *irrefragable*, the *most resolute*, the *angelical*, the *seraphic doctor*,—it was that all inquiry had well nigh

ceased, and the minds of men were cast, with a very few exceptions, into a profound slumber, and filled only with the romantic visions of an imaginary philosophy.—Such had been the state of things at the time of Lord Bacon, and the brief notice we have taken of it may serve to throw light on the real value of his labours, which had for their object the establishment of a philosophy that is in fact no other than the philosophy of reason and common sense, in opposition to all mere theory and fancy, and to all imposition.

Under these circumstances Bacon wrote his *Organon*. His qualifications for this bold attempt to clear the barren wastes of science, and to sow the seeds of a new creation of useful knowledge, will be best seen by studying his doctrines. We shall, therefore, now proceed to give an account of this most important and considerable part of his general work, the *Instauratio Magna*, or *Instauration of the Sciences*. Its title was probably suggested by Aristotle's *Organon*, containing his Logic; it is called *Novum Organon Scientiarum*, or a new Method of Studying the Sciences, from the Greek word *organon*, which signifies an instrument or machine. The grand principle which characterizes this great work, and by the proper use of which its author proposes the advancement of all kinds of knowledge, is the principle of *Induction*, which means, literally, *a bringing in*; for the plan it unfolds is that of investigating nature, and inquiring after truth, not by reasoning upon mere conjectures about nature's laws and properties, as philosophers had been too much accustomed to do before, but by *bringing together*, carefully, and patiently, a variety of particular facts and instances; viewing these in all possible lights; and drawing, from a comparison of the whole, some general principle or truth that applies to all. The foundation of this philosophy lies, in short, in the *history of nature itself*—in making a laborious collection of the facts relating to any one subject of inquiry, previously to any attempt at forming a system or theory. Actual experiment, which Bacon significantly terms “asking questions of nature,” must be resorted to, where experiments, as in chemistry, can be made: observations must be accurately collected, in the subjects proper to these, as astronomy; and conclusions are, in all cases, to be drawn only from what is actually witnessed, after the comparison of a sufficient number of facts, and a due regard to objections. In his treatment of this important subject of Induction, a new and more rational employment of the faculties is exhibited than the world had ever seen; and never before was there laid down to the minds of men the true theory of investigating all truth, whether natural or moral: indeed, Bacon has well merited the appellations he has received—the *Prophet of the Arts*, and the *Father of Experimental Philosophy*.

To point out the amazing success which has attended this system, which may be called the *Baconian* method, in the hands of the moderns, were an endless task—it would be to give nothing less than the history of science for the last two hundred years. The constellation of geniuses that rose in the next age mostly looked up to Bacon as their leading star. Newton himself was able to outshine them all, not merely by the energy of his own mind, but by his imbibing most deeply the spirit of this philosophy. No feature of Newton's intellect was more remarkable than the singular command he possessed over his

imagination, by which he was enabled to construct theories, more surprising than all the visions of fancy, yet on a foundation that must remain unshaken so long as the human mind and truth continue what they are. We may name his *Optics*, in passing, as a triumphant example of the *Inductive* method, in which, by experiment and observation as the basis of his calculations, he has treated of the nature and properties of *light*, one of the most subtil of all things, in a manner that cannot fail to surprise and delight the reader: with so much accuracy and precision is this wonderful element reduced to certain laws, as truly as the most gross and solid bodies. Having found, by very accurate experiments, that light always proceeds in straight lines, and that the rays of it are reflected and refracted according to certain fixed and unchanging laws,—on this experience he establishes the whole theory of *optics*, or the science of *vision*; and thus this science is founded on the *induction* we speak of.

Again—the mere falling of a heavy body to the earth was found by Newton to involve principles which apply to all we know in mechanical philosophy; in other words, the descent of a tile from a house, or an apple from a tree, arises from the same cause which keeps the moon from leaving her proper course round the earth; and which retains all the planets in their paths round the sun: this principle, or cause, is called by the name of *gravity*. It was known from observation that gravity, or a tendency to approach the earth, belongs generally, to all bodies near its surface; and it was ascertained that it is proportioned to the square of the distance; that is, if a body be attracted by the earth at a certain distance, with a certain force, and be afterwards removed to *twice* the distance, it will now be attracted *not half* as much, but only *one-fourth* as much as it was before; and if it be removed to *three* times the first distance, it will be attracted *not one-third* as much, but only *one-ninth* as much as before, 4 being the square of 2, and 9 the square of 3. From these facts this mighty genius suspected that the same principle might extend to all nature; and thus, by the assistance of a profound geometry, he explained the motions of the heavenly bodies, and demonstrated the system of the world.

That the rules laid down by Bacon had been carefully studied by Newton, is evident from the use he makes of Bacon's phraseology. In his *Principia*, for instance, he gives the same latitude of meaning to the word *axiom* that Bacon does in his *Organon*. Bacon, by this term, means a general principle, obtained by experiment and observation, from which we may safely proceed to reason in all other instances; and Newton gives the name of *axioms* to the *laws of motion*, which of course are ascertained by the scrutiny of nature; he also terms *axioms* those general experimental truths, or *facts*, which form the groundwork of the science of optics. *Axiom*, however, in the language of Euclid, and of mathematicians generally, means a self-evident proposition. Mr. Dugald Stewart thinks that, in this, and other instances, Newton followed Lord Bacon's phraseology "too implicitly." However this may be, it is certain Newton was familiar with Bacon's works.

In the *Chemistry* of modern times, also, we have the most astonishing examples of the success of the inductive, or experimental method. Until

this was employed, no part of science was more fanciful: so that it has justly been remarked, that chemistry, in the middle ages, might be said to have an *elective attraction* for all that was absurd and extravagant in other parts of knowledge. It is true that, before the darkness of these ages had passed away, *Paracelsus* conferred great benefits on the world by the application of chemistry to medicine; and *Van Helmont*, notwithstanding the extravagancies with which his imagination was filled, by the discovery of elastic fluids, did his part to form the new chemistry; but it was the work of those who have had the opportunity of thoroughly imbibing the spirit of the Baconian philosophy, as applied by Newton, effectually to deliver chemistry from quackery and romance; and to frame such a system as that which now exists.

Lord Bacon, in support of the importance of the *inductive method*, ✓  
lays down the following fundamental principle, as his first and  
leading *aphorism* concerning the “Interpretation of nature, and man’s  
dominion over it”—a principle which, obvious as it seems, had never  
been properly acted on by philosophers:—“Man, the servant and ✓  
interpreter of nature, can only understand and act in proportion as  
he observes or contemplates the order of nature; more he can neither  
know nor do.” This general principle of Bacon is undoubtedly  
the foundation of all our real knowledge. The science of the phi-  
losopher differs in degree only, *not* in kind, from that information  
which is the fruit of the commonest experience. Everybody knows  
that cold produces ice and snow; that the sun is higher in the sky  
in summer than in winter; that in pits and mines the air some-  
times burns, and explodes like gunpowder. Now the moment we  
depart from these mere facts, and begin to consider their causes, and in  
what circumstances they are likely to happen again, we begin to apply  
*experience* to science—we reason by *induction*. It cannot be doubted  
that this inductive method is, to a certain extent, natural to the mind.  
The foundation of it lies in our expecting the *same effects from the same*  
*causes*; for this is the groundwork of reasoning from particular facts to  
general, or what is called “*generalisation*.” This expectation seems  
to be an original principle implanted in the human mind by the benefi-  
cent Creator; and without which we could know nothing, and never be  
safe from danger. It goes before experience, and is the guide of it.  
A child who for the first time approaches too near the flame of any sub-  
stance that is in a state of combustion, or burning, so as to hurt himself,  
afterwards proverbially dreads the fire; connecting in his mind the  
remembrance of the pain he has felt, with the touching of any part of  
his body with the flame. It is evident he expects the same effect to  
follow from the same or a similar cause; and the resemblance between  
the flame of a candle and that of the fire would, it is likely, put him on  
his guard against a similar disaster from that source also. Now, this  
is a species of *induction*, though not founded on an enlarged expe-  
rience; and it is probable the child will now come to have the same  
fear of everything bearing the appearance of flame. He might expect  
that the same effect must arise from contact with the flame of *alcohol*,  
or spirit of wine, for instance, until informed that it was possible to touch  
this without being burnt. Hence the necessity of a sufficient experience,  
before we form any general principle.

A remarkable instance of this necessity, and one drawn from the more exact part of science, is mentioned by Euler, in his *Memoirs of Berlin*. It happens that in the formula  $x^2 + x + 41$ , if  $x$  be made successively equal to 0, 1, 2, 3, 4, 5, etc., the results will be a series of which the first forty terms are all *prime* numbers—that is, numbers which have no divisors, or which cannot be divided into any number of equal integral parts, less than the number of units of which they are composed: hence it might be supposed the law was general;—or, in other words, for the sake of any of our readers who have not made themselves acquainted with algebra, that any number whatever, multiplied by itself, and then added to itself, together with the number 41, would make a prime number. It happens, however, that in the very next, or forty-first term, the result is a *composite* number—that is, a number that can be divided by some smaller number, without a remainder; and thus the rule is false. Now, it is the great design of the *Novum Organum* to point out the method of a strict and enlarged experimental, or inductive reasoning, especially, though by no means exclusively, in reference to the study of *physics*, or natural philosophy. This work may be regarded as a more useful and more extensive system of reasoning than any that went before it; not consisting of *sylogisms* and the modes of argument that were then in use, which, however correct, provided the premises be true, could, after all, only serve for the arrangement of truths already known, or for detecting very obvious and gross fallacies in argument, and for classifying such truths and fallacies, but an art leading to invention, and productive of discoveries of the highest importance to the general uses of human life. These discoveries are proposed to be accomplished by turning our attention from mere words to things themselves; from all those frivolous and childish speculations which only dazzle without illuminating the understanding, to a sober and rational method of investigating the operations and laws of nature,—a method well calculated to recommend itself to those whose only object is *truth*.

Lord Bacon sets out by condemning the two opposite errors, which up to his time had proved equally injurious to a just acquaintance with nature; the one that of magisterially pronouncing on her operations, as if *all* were explored and known, and nothing further were to be discovered; by which supposition all inquiry would of course be prevented as useless; the other error that of the sceptic philosophers, who, proceeding to the opposite extreme, declared that *nothing* can be known, and endeavoured, by distrusting the clearest notices of sense and consciousness, to convince themselves of this absurd and inconsistent notion. Those of the ancient Greeks were more worthy of our imitation, whose writings are now lost, but who seem to have held a middle course; and though they complained of the mystery in which nature often wrapped herself, still kept on their pursuit, and did not allow themselves long to lose sight of their object. Even these philosophers, however, do not appear to have applied a sufficient *rule* and *method* in their inquiries, but placed too much reliance on subtilty of mind, and random conjecture. The art of logic, so much extolled by the ancients, certainly came too late to minds already prepossessed by error: hence, by the perversion of this instrument, the aberrations

of the human understanding were only fixed and rendered permanent, instead of being corrected and removed; the chains of prejudice were rivetted, and loaded with gaudy ornaments. It is evident that the mind needs direction and regulation, by some right method of employing its faculties, as much as the body needs the assistance of the mechanical powers in raising large and heavy weights. In such a method the ancients were altogether deficient. Yet by way of conciliation, Bacon observes that he is still perfectly willing to leave the ancients in possession of all the honour that is due to them. The method of science, however, here proposed, being so little known to them, no room, he conceives, is left for rivalry and envy. He contends not for victory, but for utility and truth. If any persons, from want of time, or other causes, are unable to pursue this more laborious method, he says they may still attempt what they can, by framing systems and theories, which he terms the mode of *anticipation of the mind*; others, who are more worthy sons of science, must follow *his* plan of induction, or *the interpretation of nature*, as it is here laid down, a method on which it is the more necessary to insist, because many examples have occurred since Bacon's time, of the bad consequences of neglecting it. Of this, no less names than *Descartes* and *Leibnitz* were early examples; men endowed with every faculty of the mind that most fits for philosophical investigations—with the happiest genius for science.

The body of the *Novum Organum* is divided into two general parts. The former of these, which is intended to introduce the latter, is calculated to prepare the mind for receiving and employing the doctrine contained in the second part, which delivers the new method of proceeding in all kinds of inquiries, in order to the acquisition of a more accurate knowledge of the works of nature, and a more extensive dominion over it. As the whole book is quaintly divided into *aphorisms*, or short portions, founded on sententious remarks, and accompanied with illustrations, we shall not attempt to conduct our readers through each of these portions separately, which would be almost to present the whole; but hoping that those who have the opportunity of doing so, will feel induced to read the original work, or a translation of it, for themselves, we shall simply endeavour to condense its principles, and shall throw it into sections adapted to our present purpose.

### I. General Prefatory Remarks.

The first thirty-seven aphorisms, which we may call our *first section* of the former part of the work, are chiefly occupied in attempting to remove ancient prejudices, and to procure a fair and candid attention to a book which, at the time of its publication, must have had so much to contend against. It is deplored by Bacon, that for want of a right method of study, little effects had resulted, up to the close of the sixteenth century, from the labours of men engaged in the pursuit of science; for knowledge is the same thing as power, and where there is little sound knowledge of nature, there will be little power gained over her. This must always have been the state of things, unless means before untried had been employed in the improvement of the

sciences. That improvement could not be left to mere accident as heretofore, when each following age only re-echoed the voice of the preceding, and contented itself with pompously extolling the existing delusive methods of philosophy, to the neglect of one more genuine and scientific. The philosophy of nature Bacon compares to "a vast pyramid, which ought to have the history of nature for its basis:" those who strive to erect it by the force of abstract speculation, he likens to the giants of old; who, according to the poets, endeavoured to throw mount Ossa upon Pelion, and Olympus upon Ossa. The only hope on which to found all real advancement in knowledge, must arise from a strict experimental method, that is, the examination of a sufficient number of particular instances on both sides the question at issue, so that when all the exceptions are properly made, some useful and important truth may remain as a principle to proceed on, in further inquiry. When examined on this inductive principle, most of the common notions existing when the *Novum Organum* was written, were quite unsatisfactory: those, for instance, relating to *gravity, attraction, the elements, matter, form*—all these, and many more, as taught in the sixteenth century, were but ill-defined and fantastical notions. Even many of our common-sense ideas, as those relating to our sensations and reasonings, though they can scarcely in themselves greatly deceive us, yet may these be much obscured and perplexed by a false mode of philosophizing. For instance, the supposed necessity of the objects of sense being actually present with the mind that perceives them, gave rise to the *notion of images*—an image of a horse must be *in the mind*, or the horse could not be seen; whereas, it is evident, that *seeing* is a fact in the nature of man: how the impression is conveyed from the nerves and brain to the mind, we know not.

\* The mode of searching after truth that had always been in vogue was, at the best, from observing, not very rigidly, a few particulars, to rise at once to some *general axiom or conclusion*; but the only genuine method, Bacon observes, is, to advance gradually from the notices the senses give us in particular instances, and those sufficiently numerous, to some *lesser axiom or principle*, and then gradually to proceed to some still more general principle, till at length you form some grand and final conclusion. The understanding seems but too naturally to adopt the former of these two methods, which is calculated most effectually to prevent all advances in knowledge and science. It is the object of science to see things as they are in nature, and not in appearance merely: but "there is a wide difference," says Lord Bacon, between the *idols of the human mind*, and the *ideas of the divine mind*: that is, between certain vain notions, and the real characters and impressions that are stamped upon the creatures, as they are actually found." We may illustrate this by a reference to the Ptolemaic System of Astronomy, which was founded on the false and hasty notion of the *apparent* motions of the heavenly bodies being the *real* ones. The sun, moon, and stars, seem to move round the earth once in twenty-four hours: hence the rude and gothic notion that the earth was the centre around which they are all actually whirled; whereas, by a successful cultivation of a proper method, the truth is now demonstrated to be that the sun, and not the earth, is the centre

of the mundane system; and is, with respect to the earth at least, nearly at rest. "The method of *anticipating nature*," says Bacon, "rash, hasty, and unphilosophical as it is, has nevertheless a much greater power than the other, to entrap the assent of the mind; which is too apt to be delighted with its own conjectures, and to allow the imagination to be struck and filled with its own plausible subtleties: whereas *interpretations of nature*, or real truths arrived at by induction, being separately and more slowly collected, cannot so suddenly arrest the mind; and when the conclusion actually arrives, it may so oppose prejudice, and appear so paradoxical, as to be in danger of not being received, notwithstanding the evidence that supports it, "like mysteries of faith."

The method of *anticipation*, however, or of dictating to nature what she and her operations are to be, could never, of course, avail to promote real science, whatever talents might be engaged in it. *Tycho Brahe* thus *anticipated* nature, in taking it as a certain truth that the earth must be at rest. For though he was too well acquainted with the planetary motions to suppose their centre any other than the sun, yet in order to preserve his favourite notion that the earth did not move, he supposed the sun, with all the planets, to be carried annually round it; while these latter revolved in their proper orbits round the sun: and having rejected the Copernican doctrine of the daily motion of the earth round its own axis, he was obliged to retain the most violent part of the system of Ptolemy, and to suppose that the whole universe was carried round the earth every day. It was thus, also, that the great *Kepler*, the contemporary of Bacon, imagined that the planets *must* be six in number, and must have orbits of certain dimensions, because of certain properties of numbers, and of plane and solid figures, with which he fancied they corresponded. These speculations he published in 1596 in his "*Mystery of the World*;" and on sending a copy of his book to Tycho Brahe, he received from him the advice, "first to lay a solid foundation in *observations*, and then, by ascending from them, to strive to come at the causes of things." To this excellent advice, as Maclaurin observes, we owe Kepler's more solid discoveries: for, availing himself of Tycho Brahe's astronomical observations, he, from them, discovered the laws of the planetary motions, known ever since by his own name. *Huygens*, a celebrated Dutch geometrician and astronomer, and who lived later, suffered himself to be imposed on in a similar way: for, having discovered one of Saturn's moons, this, added to the four moons of Jupiter, and the one belonging to our globe, made up the number six; the number of the primary planets then known being also six; and the number six being a *perfect* number—that is, a number that is equal to the sum of the equal parts into which it can be divided, Huygens affirmed that the number of the planets was complete, and that it was in vain to look for any more: we need not remark that this mystical speculation has since been disproved by fact. Now it was the praise of Lord Bacon to endeavour to remove from men's minds this superstitious tendency to rest in preconceived notions, which so much prevailed, and which was encouraged by some who were greatly his superiors in the abstract sciences. "Though the labours and

capacities of all men," says he, "in all ages, could be united and continued, they could effect no considerable progress in science by *anticipation* of nature; since radical errors in the mind's first digestion are not to be cured by the excellence of its functions, or by any succeeding remedies. Unless men choose to move always in a circle without advancing, we have but one simple method left; namely, that of leading them to particulars, to their order and connection. They must be contented, for a time at least, to forsake their own notions, and to become acquainted with things themselves. Our method has some resemblance to that of the Sceptics at the outset, but differs widely from it, and is directly opposed to it in the end. They foolishly assert that nothing can be known: we say that little is to be expected from the existing method; they contradict reason and common sense; we endeavour to assist both."

## II. *The Idols of the Mind; or Grand Sources of Prejudice.*

Lord Bacon philosophically points out, with great exactness, various general sources of those *errors* which men are apt to commit in forming their notions of things; and he shows how very great an obstacle they form to the progress of our knowledge, and the acquisition of truth. "The *Idols*, or false notions of the mind," he says, "so deeply fix themselves in it, that they not only shut up the avenues through which truth might enter; but even when it has entered, they will again be presenting themselves, and will be troublesome in the advancement of the sciences, unless men, being aware of them before hand, guard against them with all possible diligence." As no part of Bacon's works is more valuable than this, or more important to all who are in pursuit of knowledge and truth, we shall give some detail of it to our readers. He strikingly, though in his usual quaint style, calls the prejudices that check the progress of truth, by the name of *Idols*, because mankind are apt to pay homage to these, instead of regarding truth; as they have offered to imaginary deities, the worship which is due only to the true God.

These prejudices and prepossessions are divided into four classes, which are called *Idols of the Tribe*; *Idols of the Den*; *Idols of the Market*; and *Idols of the Theatre*. These sources of error are peculiarly deserving of notice, because they will be found, if we mistake not, to include the principal causes, which in all cases have a tendency to obstruct the pursuit of truth, whether natural or moral. They constitute a sort of infection from which the mind must be purified, before it can enter with soundness and vigour, and with the best effect, into any sort of inquiry which has truth, and truth only, for its object. "While the rules Lord Bacon gives us," says the late Dr. Thomas Brown, "are rules of physical investigation, the temple which he purified was not that of nature itself, but the temple of the mind; in its inmost sanctuaries were all the idols which he overthrew; and it was not till these were removed that Truth would deign to unveil herself to adoration."

1. The *Idola Tribus*, or the *Idols of the Tribe*, the first class of prejudices, are so called because they are common to the whole *tribe*, or *race* of mankind; they are, in fact, those general prejudices which arise

*from the infirmity of human nature itself.* "The understanding of man," says our author, "is like a mirror whose surface is not true, and so, mixing its own imperfection with the nature of things, distorts and perverts them." For instance, there is a tendency in the mind to suppose a greater *uniformity* in Nature than she actually possesses. We are always disposed to imagine parallels, correspondencies, and relations that may not actually exist. Hence the supposition that the heavenly bodies must all move in perfect circles, because the orbits of the planets were perceived to return into themselves: this was universally believed by the old astronomers, till Kepler disproved it a few years before Bacon wrote, by showing that the planets move in elliptical or oval orbits. Hence the ancient notion that the element of fire, with its *orb*, must be added to air, earth, and water, to make up the *even number* of what they called the *four elements*. Bacon's prediction that the sources of error would return and be likely to mingle with science even in its most flourishing condition, has been verified with respect to this particular illusion, in the case of sciences which in his time were scarcely in existence. When it was found that a considerable part of the earth's surface consisted of minerals, disposed in horizontal strata, or layers, it was immediately concluded that the whole exterior surface either is or has been composed of such layers; and on this assumed principle entire theories of the earth have been constructed.

Again, the mind has a wonderful facility also of being imposed on by *prepossessions*. If once pleased with any notion, it immediately endeavours to make every thing agree with this, even in the face of evidence to the contrary. It gets over opposing instances and examples, either by altogether neglecting them, or by inventing some subtil distinction which shall still maintain the favourite principle with which it first set out. Dreams, omens, and astrological predictions are cases of this kind, in which the instances of failure are passed over by the superstitious with little notice, while those instances in which the event corresponds to the supposed preternatural intimation of it are carefully remembered. This prepossession of the mind cannot endure exceptions to rules, and negative instances; though these are, in fact, of the greatest importance in establishing axioms or general principles.

The *imagination*, also, is apt to be overpowered with whatever at once strikes and seems to fill it; and the mind, imperceptibly yielding to this impression, readily comes to some conclusion, not waiting for the gradual processes of the understanding, to try general principles by the test of various, remote, and dissimilar instances; which can never be done without following rigid rules, and submitting the faculties to violent restraints.

The *restless activity* of the human powers, moreover, aids the force of general prejudices. The mind is ambitious of understanding what is incomprehensible. It attempts to grasp what is beyond its power, instead of being content with some proper resting-place for the natural weakness and limitation of its faculties. It wearies itself in its endeavour to comprehend such ideas as *space, time, eternity, infinity*; and it is still more apt to be misled, Bacon thinks, by its desire to discover the *final causes* of things, that is, the *uses*,

or ends, which the Creator had in view in forming them. The phrase *final cause* was first introduced by Aristotle, and the inclusion of this among *causes* in general as objects of inquiry, had the effect of diverting such minds as those of his followers from the study of nature to mere speculations. We must therefore remember that the hint which Bacon here throws out on this subject, and what he says more on it in his other works, always has a reference to *final causes* as treated by the Schoolmen. He objects to these being included, as a branch of *natural science*; but it cannot be supposed that his remarks on this subject arose from the same source which produced the prejudice against final causes that so generally prevailed in France in the eighteenth century. Bacon had no bias towards atheism: he censures Aristotle for "substituting Nature instead of God, as the fountain of final causes; and for treating them rather as subservient to logic than theology;" and in his Essays he finely remarks, "I had rather believe all the fables in the Legend, and the Talmud, and the Alcoran, than that this universal frame is without a mind. While the mind of man looketh at second causes scattered, it may sometimes rest in them, and go no farther; but when it beholdeth the chain of them confederate and linked together, it must needs fly to Providence and Deity."

Notwithstanding Lord Bacon's objection to final causes as a subject of philosophical inquiry, it must be allowed that, apart from the charm which the final causes, or ends of things, lend to Nature, when they are satisfactorily perceived, which is the moral use of them, there are some cases in which a consideration of them has conducted to actual discoveries in science. It was noticing the situation of the valves in the veins of the animal body, for instance, that led to the great discovery of the circulation of the blood. Harvey, who was its author, perceived that these valves, in some parts of the body, were so placed as to give a free passage to the blood towards the heart, and to exclude its return the same way. He thought there must be some particular *design* in this, and no design appeared more probable than that, since the blood could not well, because of the interposing valves, be sent by the veins to the limbs, it should be sent through the arteries, and return through the veins, whose valves did not oppose its course that way. This fact, however, and others which might be mentioned in illustration of this subject, were not known to Bacon; and the great abuse of the speculation on final causes by the Schoolmen not unnaturally led him to an unreasonable distrust of it.

The influence of the will and affections on the understanding, or what may be termed the moral state of the mind, may also greatly affect our opinions. "The light of the understanding," says our author, "is not a dry or pure light, but it receives a tincture from the will and the affections, and forms the sciences accordingly; for men are most willing to believe what they most desire." Hence, he observes, "difficulties are rejected through impatience; the deeper things of Nature are dreaded through a certain awe; experience is discarded through pride; truth when it limits our hopes; paradox is shunned through fear of vulgar opposition; and thus in innumerable ways, and often imperceptibly, do the affections and passions tinge the understanding with their own colouring."

The fallacy and incompetency of the senses are an additional

source of mistake and error. Inquiry commonly ends in what is seen on the mere surface of things, while the organization, the texture, or the inward changes of bodies are unknown. On these, however, chemistry depends." Lord Bacon considers this incompetency and dulness of the senses as one of the greatest impediments to an exact knowledge of nature. "Nor can instruments," he adds, "here be of any great service, since all true interpretations of nature must be made by suitable and proper trials, in which the senses judge of experiment only, and experiment is the judge of nature and fact." He complains, by way of example, that in his time even the properties of the common air of the atmosphere, and of all the agents, still more subtil than the air itself, of which he supposed there might be many, were almost entirely unknown. What would he have said, could he have witnessed the application of the inductive philosophy to the discovery of the properties of the various kinds of *gases*—the researches of Newton respecting *light*—the experiments of Franklin in *electricity*—the powerful agency of *galvanism*, which has produced new creations in chemistry, and changed the whole face of that interesting and useful science!

Lastly, there is a tendency in the mind to abstraction or generalisation, which should be carefully watched as a likely source of error. It is less troublesome to reason upon fancied general notions, than to make experiments. "But Nature," says our author, "must be anatomized rather than abstracted: matter should be considered in all its states and transformations; so ought motion and its laws; but for the Aristotelian abstract *forms*, they are *idols* or *figments* of the mind."—These seven particular causes, then, may be borne in mind as among the chief general prejudices, which are apt, often insensibly, to militate against the discovery of truth, and the advancement of science: too great a tendency to suppose a perfect uniformity in nature; hasty prepossessions in respect to some favourite idea; the influence of the imagination; the restless activity of the human mind; the bias the will and affections give to the judgment; the imperfection of the organs of sense; and the love of abstractions and generalisations.

2. The second class of prejudices introduced by this sagacious observer of human nature, as tending to obstruct the progress of truth and knowledge of all kinds, he terms *Idola Specus*—*Idols of the Cave or Den*: that is, those prejudices which stamp upon each mind its own peculiar character, and are identified with every individual man. "Idols of the den," says the *Novum Organum*, "are the idols of each particular person; for in addition to the general waywardness of human nature, every man has his own peculiar *den* or *cavern*, which breaks and corrupts the light of nature,—either on account of his constitution and disposition of mind—his education and the society he keeps—his course of reading and the authorities he most respects—his peculiar impressions as they may be made on a mind that is pre-occupied and pre-possessed, or is in a calm and unbiassed frame: so that the human spirit, as it is differently disposed in different individuals, is a thing fluctuating, disorderly, and almost accidental. Hence Heraclitus well observes that men seek the sciences in their lesser worlds, and not in the great and common world of nature." In another place, these idols of the den are spoken of in the figurative language of Bacon, as "each man's

particular demon, or seducing familiar spirit;" and again, every mind is compared to "a glass, with its surface differently cut, so as differently to receive, reflect, and refract the rays of light that fall upon it."

Some of these private prejudices he justly regards as requiring peculiar caution, because they possess the greatest tendency to pervert the mind. *The particular studies*, for instance, to which a person has been addicted—more especially, if he has any claim to be an inventor, may warp his judgment in other pursuits, and tend to corrupt his notions. It was in this way that Aristotle, through his fondness for distinctions and quiddities, made his natural philosophy a mere slave to his logic, and so rendered it little else than a useless source of disputation. *Gilbert*, of Colchester, is another example. In his "*Treatise on the Magnet*," he gives a specimen of experimental inquiry carried on with considerable correctness and success; but he tried to make his magnetism a general principle, considering it to pervade all Nature. It is but fair to acknowledge his merit however, for "to him," as Dr. Priestley observes, "we owe a great augmentation of the list of electrical bodies, and of the bodies on which electrics can act: though his theory on this subject is imperfect, he may justly be called the father of modern electricity." Of late years, this species of fondness for theory has been discovered in attempts to account for the motion of the planets by electricity; and electricity and galvanism together have been employed to explain gravitation, the affinities of chemistry, and even the laws of vegetable and animal life. At an earlier period Des Cartes, after Bacon had so well written against theories, endeavoured, in medicine, to combine Van Helmont's doctrine of *fermentation* with his own beloved notions respecting *vortices*; which he thus brought down from heaven (where, as he supposed, they guided the planets in their orbits) to earth, in order to explain the chief functions of the animal body. Hence he formed a chemico-mechanical system of medicine which was eagerly received by the Dutch physicians of his time. Thus may one favourite pursuit be suffered to give a tincture to every other branch of knowledge, and to corrupt it. "The tribe of chemists," says Bacon, "have constructed a fantastical philosophy from a few experiments of the furnace." None certainly of the professed inquirers after truth, up to his time, were ever more extravagant and fanciful than the experimenters in chemistry; witness the Archæus of Van Helmont, and his army of spiritual agents, derived from the elastic fluids. ↵

Among the private prejudices or the sources of error arising from the mental constitution of individuals, the natural *difference of men's capacities* is enumerated. Some minds, Lord Bacon thinks, are fitted more for discrimination, while others content themselves with merely noticing resemblances. "The great and radical difference of men's capacities," he says, "as to philosophy and the sciences, lies in this, that some are stronger and more fitted to observe the differences of things, and others to observe their correspondences: for a steady and sharp genius can fix its contemplations, and dwell and fasten upon all the subtilty of differences; whilst a sublime and ready genius perceives and compares the smallest and most general agreements of things. Both minds easily fall into excess, by grasping either at the dividing scale or the shadows of things."

With greater clearness and perspicuity, he adds to these personal

prejudices and tendencies, the *attachment to times*, in forming our ideas of truth and excellence. Some men have cherished an idolatrous admiration of the ancients; and have scarcely allowed even a comparison to be made between their works, and the monuments of modern genius. Thus the poetry of Milton has been underrated by those who have been so devoted to the remains of classical antiquity, as to be almost incapable of awarding due merit to productions in the vulgar tongue: witness the contests respecting the superiority of ancient or modern learning. On the other hand, while every thing modern has been despised only because it is not ancient, some have been misled by the opposite cast of mind, and have been inflamed with a constant passion for novelty; being disposed to yield little or no respect to antiquity, even where the experience of past ages might be of great service to us. This kind of prejudice has greatly declined, however, since Bacon's time—*truth*, and not the establishment of sects, having happily become the leading object of philosophical inquiries; “for truth,” says he, “is not to be derived from any felicity of times, which is an uncertain thing, but from the light of nature and experience, which is eternal.”

He exemplifies another kind of *particular prejudices*, or of the *Idola Specus*, by comparing the school of Leucippus and Democritus, among the ancients, to the “other philosophies,” alluding probably to those of Pythagoras, and of Socrates, Plato, and the Academics. Leucippus, Democritus, and Epicurus were *atomists*,—they taught that the whole universe is composed of either *atoms* or a *vacuum*, and that it was by the accidental meeting together of these atoms that the world assumed its present form and appearance. “This school,” says Bacon, “is so taken up with the particles of things, as almost to neglect their structure; whilst the other views the fabrication of things with such astonishment, as not to attend to the simplicity of nature;” referring to the lofty speculations and flights of imagination that characterized the Platonic school. ) “To contemplate nature and bodies in their simple elements,” he quaintly remarks, “breaks and grinds the understanding; and to consider them in their configurations and compositions blunts and relaxes it.” This *exclusive predilection for the minute or the vast* in nature, by which some of the ancient schools were marked, much resembles the second order of prejudices which is mentioned under this class. “In this manner, then,” concludes the account of these prejudices, “let contemplative wisdom proceed in dislodging and chasing away the *idols* of the *den*, which principally have their rise from *prevalent studies*; *excess of composition and division*; *affections for times*; and from the *great or small size of objects*.”

3. Another class of prejudices to be carefully avoided in our inquiries after *truth*, are termed, in the figurative but expressive language of Lord Bacon, *Idola Fori*; *Idols of the Market-place*; that is, *prejudices arising from mere words and terms in our common intercourse with mankind*: they proceed, in short, from the *imperfection of language*. These prejudices he pronounces “the most troublesome of all.” “Words,” says he, “are for the most part accommodated to the notions of the vulgar, and they define things by bounds that are most obvious to common minds; and when a more acute understanding, or a more accurate observation, would remove these boundaries, and

place them more according to nature, words *cry out and forbid.*" A familiar instance of this may be taken from our common mode of speech with regard to the heavenly bodies. We say of the *sun*, that it *rises* and *sets*, though every one, but the most ignorant, is aware that this is not strictly true, since the sun is stationary with regard to the planetary system; its *apparent* motion being owing to the *real* motion of the earth. In this instance, however, the delusion which words might produce, is obviated by the popular knowledge of astronomy which prevails. In many cases it is certain that the want of accuracy in the use of words and phrases has proved a great barrier to the pursuit and attainment of truth. How many violent disputes have there been, for instance, on *liberty* and *necessity* among ethical writers, while neither party has taken the pains first to say what he meant by these words; which might have saved both much time and much angry contention. Hence, in order to avoid controversies respecting mere words and terms, it is recommended to begin with these according to the "wise method of the mathematicians," and to reduce them to order and certainty by *definitions*. "Yet," it is justly observed, "these definitions themselves cannot wholly remedy the evil; for definitions consist of words, and words produce words; so that recourse must be had to particular instances."

Lord Bacon's meaning may be illustrated by such words as *sensation*, *will*, *benevolence*. We may define sensation, and say it is *feeling*, but what is *feeling*? What, for instance, is the feeling or sensation of *cold*? What is the sensation of *seeing*? None can describe these, it is obvious, to a person supposed never to have experienced them. *Will* may be defined *volition*, but this again is a mere translation; and if an intelligent being could be imagined who had never actually *willed* any thing, nor ever had any *desire* in his mind to do or say any thing, it would be utterly impossible to make him understand what *willing* is. A being of simple malevolence, or one who had never felt towards other beings any thing but *hatred*, could have no idea of the emotion of *benevolence* towards others: he could not know what it is to love them. But when a child once understands that *sensation* is a general name for all those immediate effects which arise from objects acting upon any of the organs of sense—a name for *seeing*, *hearing*, *smelling*, *tasting*, and *feeling* indifferently; when he learns that *willing* is that state of the mind which directly goes before any deliberate action; or that *benevolence* or *love* is a term expressing certain natural and delightful emotions towards his parents, brothers, sisters, and friends,—he then understands the meaning of these words by instances and examples. Or, if I wished to convey to the mind of another person the meaning of the word *gravitation*, or *attraction*, as it is employed in the Newtonian philosophy, instead of merely saying it is the *tendency* bodies have *towards each other*, I might state the simple fact, and say, when a body is let fall from any height it proceeds invariably to the earth, and more swiftly in proportion as it arrives nearer the surface: this is what is meant by saying that the body is *attracted*, or *gravitates* with accelerated velocity toward the earth: and when the inquirer is further informed that the earth itself also proceeds, however little, toward the falling body; and that the sun, moon, earth, and planets, all mutually move toward each other, more or less, in the same man-

ner, the general idea of what is intended by attraction or gravitation is gained; and it is understood simply to be a name for a certain *fact*, or *law* in the operations of nature, or rather of nature's Divine and Almighty Architect.

Mankind are apt to be led into errors by words in *two* principal ways; and first by the names of *things* which have *no existence* whatever. Of this kind, says Lord Bacon, are such as "fortune, the *primum mobile*, orbs of the planets, the element of fire, and the like figments which arise from false and imaginary theories." It is almost unnecessary to remind our readers that all such words as *chance*, *fortune*, *luck*, etc., are only names for human ignorance of a cause; and that in all the cases in which these words are applied to any kind of circumstances that occur either in the natural or moral world, there is the same necessity for supposing an agency of the Deity as in the greatest, and, to us, most certain events. *Primum mobile*, or the first mover, in Ptolemy's astronomy, was a supposed immense sphere, or hollow globe, which included within it all the spheres, or *orbs of the planets*, and fixed stars, and turned itself and all these round the earth in twenty-four hours! Idols of this kind, however, it is observed, are the more easily dislodged from the mind, because the direct remedy for them is the constant rejection of all mere theory.

But there is another species of delusion which may arise from words, that is likely to produce greater perplexity, and is avoided with greater difficulty. This delusion is produced when words do not agree to the things they are intended to signify, but are confused and ill-defined. Bacon adduces the various meanings that were formerly given to the word *humidum*, or *moisture*, as an example of this uncertainty: he shows that, according to the vague manner in which the word was used, it would apply to the most dissimilar things, and that *flame*, and *small dust* or *powder*, and *glass*, might all, on this principle, be said to possess *moisture*. It is evident that this uncertainty in the application of the term *humidity* or the quality of *moisture* arose from not considering moisture as a *relative* idea. For instance, quicksilver, with relation to some substances, as our hands or our clothes, is *not humid*, but it may be regarded so with reference to tin, lead, or gold; for it will adhere to their surfaces and render them soft and moist. Even water does not wet all things, for it runs off in round drops from the leaves of many plants, the feathers of birds, etc.; so that water itself is no more moist with regard to these, than quicksilver is with regard to our hands; unless by moisture we mean soaking with water merely. Our great philosopher complains that, in general, the notions of *quality* in bodies, were in his time exceedingly confused. Such were the notions of *gravity*, *density*, *tenuity*, *levity*. From what we know, indeed, of the philosophism which then prevailed, all attempts to reason on these terms must have been like grasping a shadow or beating the air. The words used to express the *changes* which bodies undergo, were also extremely vague and undefined, as *generation*, *corruption*, *alteration*. So likewise general names of substances, as *earth*; and *air*, or vapour. It was reserved for the science of modern times to use a more precise language, and to aspire at a magnanimity almost unknown to the ancients—that of frankly acknowledging man's ignorance, and the limitation of his faculties, rather than taking refuge

in the darkness of an ambiguous phraseology. Our readers will perceive from all that has been said, how much accuracy and precision of language depend on the advancement of science; indeed they mutually promote each other. What has been effected in chemistry by a reformation in the use of terms is well known. An imitation of this precision, so far as the nature of the given subject will allow, must lie at the root of advancement, not only in natural, but equally in moral and intellectual science; and here, as in chemistry itself, the advice of Bergman to Morveau will advantageously apply: "In reforming the nomenclature, spare no word that is improper."

4. The last general sources of prejudice adduced, as obstructing philosophical discoveries, are what are termed *Idola Theatri*: Idols of the Theatre; or the prejudices and perversions of the mind arising from the fabulous and visionary theories and the romantic philosophies that so long prevailed in the world. "We call them Idols of the Theatre," says Bacon, "because all the systems of philosophy that have been hitherto invented, or received, are but so many stage-plays which have exhibited nothing but fictitious and theatrical worlds; and there may still be invented and dressed up numberless other fables of the like kind." Of this last remark, *Hutchinsonianism* may, in modern times, be regarded as an example, in common with all other speculations that have been opposed to the Newtonian theory of gravitation; and which will be found equally opposed to the method of science here recommended. It was strange that, in the eighteenth century, in the full blaze of that light which was, as it were, *latent* in the Baconian philosophy, and which Newton had struck out—a system, not unlike that of the *vortices* of Des Cartes, should offer once more to darken the heavens, after they had been so effectually purified from the *atoms* and the *plenums*, the *orbs* and the *cycles* of an imaginary astronomy: this, however, is but an example of the power which one favourite notion can exercise over an acute and ardent mind; for Hutchinson assumed, as the basis of his theory, that Divine Revelation was designed to teach men philosophy as well as religion; and in the Mosaic account of the creation, he fancied he saw the physics of the true astronomy. His system, however, which may be considered as a kind of physico-theological romance, has been permitted to sink into its merited oblivion, while Revelation is now regarded as confined to its own sublime and proper province of making known the will of God to man, as to his conduct here, and the way of attaining felicity hereafter. The Newtonian philosophy cannot, on any consistent principles, be regarded as at variance with the communications of the Bible; and, founded as it is on the basis of *demonstration*, it cannot fail to stand the test of time. Gratuitous theories may impose on the imagination, like the *mirage* of the Egyptian sands; but, like this illusion, they must pass away: they may present to the eye a magnificence as gaudy and seducing as the *fata morgana*, sometimes witnessed on the coast of Calabria, in which the most beauteous landscapes, crowned with picturesque villages, superb palaces, and massy towers, seem to possess a real existence: all, however, is only suspended in the air, and the enchanted scene changes with the least shifting of the light, or the ruffling of the sea, melting away like a dream of the night—so must vanish at last all systems of philosophy and science that are not

founded on the solid basis of that *induction*, which it is the design of the *Novum Organum* to explain. ←

This source of error and prejudice, or the *Idols of the Theatre*, are more especially to be marked as closely connected with the *authority of great names*; and thus, not unfrequently, enslaving the understanding to an ignoble bondage, by what the schoolmen term *argumentum ad verecundiam*, or the argument addressed to the modesty of human nature. Prejudices of this kind stand on a different footing from the former three sources, and are perhaps the most remarkable instances of intellectual slavery. "For," says Lord Bacon, "the idols of the theatre are neither innate, nor are they secretly insinuated into the understanding, but are plainly forced upon it, and are received from fabulous theories and *false laws of demonstration*." The importance of returning to an independent and *scientific method of inquiry*, or, in other words, of *thinking for ourselves*, is urged by our author from the fact, that "*a cripple in the right way may beat a racer in the wrong*." *The more vigorous, indeed, the mind is, which sets out in a wrong course, the further does it depart from the goal of truth and science.* The method, however, which is here proposed, is adapted not merely to a subtil understanding, and a sublime order of faculties, but is level to the capacities of all, even the humblest. To draw a straight line, or to describe an exact circle, with the unassisted hand, might be a thing scarcely to be accomplished with certainty, whilst it is an easy task to do it by the help of a ruler and compasses, with the greatest accuracy. "All these idols," says Bacon, "are solemnly and for ever to be renounced, and the understanding must be thoroughly cleared and purged of them; for the kingdom of man, which is founded in the sciences, cannot be entered otherwise than the kingdom of God—that is, in the condition of a little child."—In further illustration of these prejudices, *some notice* is proposed to be taken of the *sects and kinds* of these false theories; of their *outward signs and indications*; of the *causes* of this so great disadvantage to science; and of the reasons of so lasting and general a consent in error.

### III. *Different Kinds of false Systems of Philosophy.*

The next topic of the *Novum Organum* relates to the *different philosophical theories* which have given rise to the last of the four classes of prejudices; or the *Idols of the Theatre*. Fanciful and imaginary systems of philosophy derive no small charm, it is well observed, from their being so highly wrought: thus, to many, the fictitious drama is more attractive than true history. Lord Bacon divides these visionary systems into *three general kinds*—*sophistical, empirical, and superstitious*.

*Sophistical philosophies*, so called from their deceitful pretences, are those formed on careless and hasty observations and experiments, and filled up by the *mind of the inventor at his own pleasure*. Of this kind Aristotle's philosophy is a very eminent instance, among the other ancient systems, which were chiefly of the sophistical kind. Even the *similar particles* of Anaxagoras, the *atoms* of Leucippus and Democritus, the *heaven and earth* of Parmenides, and other *first principles* of the different sects of Greece, with all their incongruity, at

least savour somewhat of natural philosophy and experience: but Aristotle, both in his *Physics* and *Metaphysics*, utters little else than mere logical terms. Even in some of his other writings, where he makes greater use of experiment and observation, he appears to have passed a previous judgment on nature, and attempts to lead experience itself captive to his own opinions and his own humour: he forms a world of *categories* and *predicaments*; accounts for nature's varied operations by the scholastic distinction of *act* and *power*; asserts that there is but *one proper motion* in all bodies; and imposes numerous other fictions on mankind, which are sources of disputation rather than of truth. ↵

Empirical systems are those formed upon a few experiments only, though these may be made with great exactness. ↵ The ancient chemists are adduced as examples, in their idle speculations on the four elements, founded on a few repeated experiments of the furnace. William Gilbert, who lived in Lord Bacon's time, and framed, as we have remarked, a system of philosophy on his experiments in magnetism, was a notable instance of this kind. ↵

Superstitious systems are those in which certain philosophical theories are blended with religion, and the one is made subservient to the other. ↵ Of these the philosophies of Pythagoras and Plato are specimens; their theories being principally derived from their speculations on the nature and attributes of the Deity. Some theories of the earth in modern times may come under this denomination; and perhaps there is no more signal instance of this kind than the philosophy of Mr. Hutchinson, which we have noticed above. ↵ "This vanity," says Bacon, "of mixing things divine with things human is rather to be suppressed, as from it arise not only phantastical philosophies, but heretical religions."

In framing theories, the mind, it is observed, should be especially on its guard against two excesses, that of dogmatism on the one hand, and scepticism on the other, as these both tend to perpetuate prejudices, scarcely allowing the opportunity of their removal. ↵ Thus Aristotle, in order to cut off all occasion of doubting, invented questions, and resolved them at his pleasure, as if he were the arbiter and final judge of nature; while Pyrrho and his followers, on the contrary, doubted of every thing, which was an abuse of the school of Plato, where the sceptic method was first introduced by way of jest and irony, to oppose the more ancient dogmatists. ↵ The former of these methods, or that of positively dogmatising, cannot but contract and degrade the mind, while the other must cast it into languishment and despair of ever finding the truth.

All these *Idols* of the mind which have now been noticed, have moreover been greatly defended and strengthened by false *proofs* and *corrupt demonstrations*. Words have been the tyrants of thoughts, and thoughts the slaves of a conceited logic, which has been associated with erroneous and hasty impressions from the senses—ill-formed notions arising from these impressions, and faulty induction, or such a method of establishing general principles, as has been the parent of all error, and the destruction of all the dignity and advancement of science. ↵ Thus it was that Gilbert limited his experimental inquiries to the loadstone; and the early chemists and their followers were

perpetually employed in the single art of *alchemy*. This word means the knowledge of the *substance*, or *composition* of any thing: and the two leading objects of the *alchemists* were, the change of the common into the precious metals, or gold and silver; and the discovery of a universal medicine—some elixir of immortality which they fondly hoped would annihilate disease, and prevent the irrevocable doom of humanity, death! ↵

#### IV. *Characteristics of false Systems.*

Lord Bacon next gives some *intimations, or signs by which false theories and systems of philosophy may be known*, so as to prevent the impositions likely to arise from them.—One is, the *origin* from which a system of philosophy is derived; which, if it be false and erroneous, whatever immediately arises from it must of course be so too. ↵ The sciences existing in the time when the *Novum Organum* was written, were almost wholly derived from the Greeks, whose philosophy, as we have seen, was chiefly of the dogmatic and disputatious kind. This was the characteristic, generally, of their several schools; the writings of the more ancient of the Greeks, who opened no schools, having been lost in the lapse of time, such as those of *Empedocles*, *Anaxagoras*, *Leucippus*, etc., who applied themselves to philosophy with greater simplicity, and with less affectation and conceit, than their successors. The source of the existing philosophy was, therefore, corrupt. ↵

↵ If any indications may be gathered from the *times* in which the ancient theories were framed, no great good, it is further argued, could be expected from these. In the ages of the Grecian philosophy, the field of observation and experience was limited by the little knowledge the ancients possessed of the habitable world. Their history, also, of past events, and of the origin of nations, was to a great degree fabulous. They considered many regions uninhabitable where great nations have been since found to exist. Their travels were extremely circumscribed, and the art of navigation was exceedingly imperfect. ↵

↵ If, moreover, we judge from the actual *effects* of the Grecian philosophy, very little can be shown to have resulted from it tending to improve the condition of mankind, during the space of so many ages. Something, indeed, may have accrued from the pursuit of chemistry among the ancients and their followers: but this has rather happened by accident than been produced by design; for all their theories were injurious to the discovery of truth. The cultivators of the magic arts, too, in their jugglery, have stumbled on some few matters; but even these have been corrupted by imposture. The *alchemists*, however, Lord Bacon allows, made not a few useful discoveries while vainly pursuing their chimerical and visionary projects. We are indebted to their labour and perseverance for the method of preparing alcohol, aqua-fortis, vitriolic acid, volatile alkali, gunpowder, and a variety of other chemical compounds. ↵

Another test of truth in philosophical systems may be derived from their *progress* and improvement: ↵ but, up to the seventeenth century, that is, for two thousand years, the sciences had been nearly stationary; or rather they flourished most in the remotest ages, and afterwards declined. Witness the decay of the Pythagorean astronomy till the time of Copernicus. ↵

Again, the *confession of the authors* themselves of the systems that had prevailed may be regarded as a testimony of the strongest kind to the vanity and inefficiency of these theories; for while these men pronounced on nature with the utmost confidence and dogmatism, we may detect them at intervals assuming a desponding air, and complaining of the obscurity and uncertainty of all things. Hence arose the school of the *Academic* philosophers, who doubted of everything, and consigned mankind to the eternal darkness of a sceptical ignorance.

The great *disagreement and opposition*, moreover, that existed among the ancients, shows, says Bacon, that "the avenues from sense to reason were not well guarded, since the one subject of philosophy was so rent and split into error, that nothing remained fixed and stable in the existing notions derived from the Greeks; nor was there any certain rule of investigation."

The opinion, also, that was entertained in the sixteenth century, that a *general consent* prevailed in the philosophy of Aristotle, was a *fallacious* argument of its truth; for the prevalence of the doctrines of Aristotle and Plato was greatly owing to the accidental circumstance of their being preserved from the general wreck of human learning, which ensued on the irruption of the barbarous nations into the Roman empire. Besides, such a consent as that which is supposed, if proved to be ever so little founded on accident, would better deserve the name of *obsequiousness*; not being the result of a free exercise of men's judgments, all centering at last in the same conclusion, but the offspring, as it is evident, of prejudice, and an abject vassalage to the authority of names. The character, therefore, of the systems of science and philosophy that had been current, was extremely unfavourable to the supposition of their truth, whether taken from their *origin*, their *fruits*, their *progress*, the *confessions* of their authors, or from *general consent*.

#### V. *Causes of Error in Philosophy.*

The next topic of the *Norum Organum*, and the *fifth* convenient section into which the former part of the work may be divided, relates to the *causes of error* in philosophical inquiry.

The first cause assigned by our illustrious author is, the *short space of time* which, notwithstanding the lapse of so many ages, had been at all productive in the discoveries of science. He beautifully compares duration to space, and places before us the emblem of a barren desert, as a fit representation of that lasting sterility which had reigned over the tracts of time. Scarcely six of all the centuries preceding the age in which he lived could be regarded as, in any degree, exceptions to this general winter of the human mind. The middle ages were proverbially periods of gross and palpable darkness. Men of leisure were found shut up in the gloom of monasteries; and rarely did a ray of genius emerge from these cloistered solitudes, and find its way into the theatre of human life, so as to improve and embellish it with inventions like those which have, in our happier times, rendered it a scene of ever new and increasing wonders.

Even at the best, the comparative *neglect* of the philosophy of *nature*, properly so called, may be regarded as another source of

the slumber of the human intellect, and of its inefficiency in attaining to anything like a just method of science. ↵ The sublimest geniuses, allured by gain, or by the love of speculation, exhausted their energies in the disputes of a scholastic theology; or, at a more early period, among the Romans, were almost wholly devoted to politics. Mathematical and natural science, the parents of all mental discipline, had lost the footing they had obtained among the remoter Greeks, almost from the time of *Thales*; and even the great moralist, *Socrates*, had contributed, in a considerable degree, to turn away men's minds from the contemplation of nature. ↵ Thus the most definite and tangible sources of our knowledge—those which are peculiarly adapted to fix and regulate the operations of the mind, by perpetually recalling its attention to what is seen, and felt, and heard, were abandoned; and the human imagination was suffered to roam in a shadowy and ærial region, amid a scenery that was not nature's creation, but its own.

Again, where some taste for the study of nature herself *did* exist, scarcely one single individual was found to devote himself *wholly* to this pursuit. Nature was still not sought for her own sake, but was made the handmaid of some profession; and to this she was enslaved. Nature was not regarded as the parent of the sciences; and these, by standing too much alone, resembled the branches of a tree attempted to be kept alive separated from the root and the trunk. }

↵ The *true end* of science also was *mistaken*, "which," says Bacon, "is to enrich human life with useful arts and inventions;" and philosophers had made it their chief object to be at the head of sects; to aggrandize their own fame; to gain dominion over the minds of men; or to obtain some other exclusively selfish end. Almost every kind of inferior aim was by turns the lord of the ascendant, while *truth*, immutable, unalterable truth, loved and sought for its own sake, was eclipsed, or cast into the shade. X

Besides, had the end itself been right, yet the *method was wrong*. As this is the main drift of the first part of the *Novum Organum*, we can scarcely insist on it too much, since nothing is more important here than to remember, that so long as any gross impropriety exists in the *manner* of investigating truth, the most strenuous labour must be in vain. All things were left, as it is strongly expressed, "to the darkness of tradition; the giddy agitation and whirlwind of argument; the waves and windings of accident; and a vague, uninformed experience." The first inquiry had always been, to know what others had said and thought on the given subject. This was usually received, and to it were added the vagaries of the inquirer himself. Such a method could, of course, only propagate and perpetuate error; and in such a state of things truth still remained shut up as in a labyrinth.

*The blind reverence for antiquity*, also, which had possessed the minds of men, and the devotedness which existed to great names, well accorded with the feeble efforts of the human intellect, and formed a striking feature in the reign of darkness. The assertion of a philosopher was almost the only specific against error, and the chief support of truth: whereas, observes Lord Bacon, "truth is justly to be called the daughter, not of authority, but of time;" in other words, time and patience alone can furnish the opportunity of that observation and experiment on which knowledge must be legitimately founded. The argument

addressed to human modesty, as the logicians termed it, was, however, often received with a kind of religious awe, even when the proposition affirmed, if, indeed, understood at all, was revolting to common sense. It certainly ought to be no subject of complaint, that this is the peculiar delinquency of the age in which we live. Even the overpowering genius of Newton has not preserved his theory from opposition in very recent times—an opposition, nevertheless, only to be viewed as the result of that most desirable freedom of inquiry, which was almost unknown to the ancients, and which can, at no period, issue in anything but the additional, or, we might say, the superfluous, confirmation of the Newtonian philosophy. To believe without examination, however it may accord with our natural indolence, is unworthy of the mind of man. In such an assent, its noblest powers are more than dormant and useless: they contract, if we may so say, by every such repetition of what is not worthy to be called *belief*, a sort of rust and stiffness, that unfits them entirely for all original and unbiassed inquiry, and which ends only in rivetting the chains of ignorance and error.

Similar in its effect to the admiration of great names, is the *tendency to be dazzled* with whatever rises, in the least degree, above the ordinary level in the productions of the human mind. Too much satisfaction and complacency in what has already been attained may have the effect of obstructing further progress. This, Lord Bacon observes, has particularly shown itself in the inventions of the mechanic arts. We are, perhaps, more ready to rest in an empty admiration of what has been effected, and to amuse ourselves with the apparent opulence of human power, than to reflect on the little progress that has been made in bringing matter under our control, and to consider the vast field that still lies open before us. After all, in mechanical instruments the ultimate principle is very *simple*—all may be reduced to a few laws of nature. In a clock, for instance, which seems, in one view, to imitate the movements of the heavenly bodies, and in another, to resemble the pulsations of animals, by its regular and successive motions, a few principles only are ultimately employed, as the law of pendulums, depending chiefly on gravitation. With what sentiments, however, would the ancients have looked on such an invention as the steam-engine, in which, nevertheless, the whole of the novelty, strictly speaking, lies in the application of the expansive power of steam! The causes of retardation in the improvement of knowledge, dwelt on in this part of Lord Bacon's work, have certainly been counteracted, in our time, by that rapid succession of inventions which has marked the increase of the sciences, though, in other respects, there would be much more to foster the complacent admiration he speaks of.


Another considerable cause of error and ignorance to the world, is placed, by this most accurate observer, in the *pedantry* of philosophers themselves, who have contrived to impose on mankind by their pompous airs, and affected manner of teaching—by the trickery of a meretricious and bombastic oratory, and by the subtil divisions and definitions they have employed; so as to inspire the vulgar with a profound idea of their wisdom, and to leave the impression that the sciences were exhausted by their learned labours, and nothing remained now to be investigated. No doubt this has, in every age, been a fertile source of obstruction to human improvement. The most dignified, and even sacred

professions have been too often degraded by a conceit and a quackery which, while it has disgusted the discerning, as the subterfuge of incompetent effrontery, and has proved an injurious bar to the exertions of modest and genuine merit, and to the progress of pure truth, has not failed to gain its own selfish ends, in the plaudits of an ignorant multitude. The only cure for this evil is the general diffusion of knowledge among all classes of society, which is, most happily, a leading feature of the present illustrious times.


The ancient and erroneous systems of philosophy obtained an additional hold on the public mind, also, in consequence of the *vanity* and the extravagant *pretensions* of not a few individuals of more modern date. Lord Bacon had to encounter this disadvantage in the very enunciation of many of the topics of inquiry to which he desired to recal the attention of the world in a just and scientific method: we allude to his notices for increasing men's acquaintance with the mineral kingdom; for obtaining more information with regard to the winds and the weather; the means of prolonging human life, and other inquiries. He complains of the weakness and imposture of many who had abused the credulity of mankind with great promises, in reference to such topics as the retardation of old age—the relief of pain—cures for the deceptions of the senses—the method of exciting the affections by sympathy, or a species of animal magnetism—the exaltation of the intellectual faculties—the transmutation of substances, as professed by the alchemists—the procuring of celestial influences—divination of future events—the revealing of secrets—and other such like conjuring. Thus, as real history may sometimes have suffered in its credit from fiction, and there are some who would consign the conquests of Julius Cæsar to the same scale of probability with the fabled exploits of Arthur of Britain, or Amadis de Gaul, so the spirit for great designs has been quenched by the dread of what might prove chimerical and romantic, and men have been contented to repose in the solemn and received dogmas of antiquity.

“So great, moreover,” adds Lord Bacon, “has been the pusillanimity and indolence of men, that they have been wont to satisfy themselves with *very slender performances*,” often exalting, with the title of new mechanical inventions, what were, in fact, nothing more than some trifling modifications of old ones—this has been another barrier, he considers, to the advancement of the sciences.

But one of the most formidable obstacles to the genuine knowledge of nature is to be found in the *superstition* which has mingled itself with the great and momentous subject of religion. We learn from Aristophanes, in his play of “*The Clouds*,” that among the Greeks, those who first attempted to assign the natural causes of thunder and storms were condemned as the enemies of the gods. Nor did some of the early Christian Fathers, as our author remarks, meet with much less severe anathemas for daring to assert, on the evidence of infallible proof, the spherical figure of the earth, and the existence of *antipodes*, or people at the other side of the globe, whose feet are opposite to ours. It is known to most of our readers that Galileo, the inventor of the telescope, was consigned to the dungeons of the inquisition at Rome, for the crime of asserting the motion of the earth round its own axis, and was con-

demned to do penance, by repeating once a week the seven penitential psalms for the space of three years!—The blending of the scholastic and Aristotelian philosophy with religion, in the middle ages, was a fruitful source of this kind. 

Lord Bacon's remarks on this subject are so just, and so important, that we shall quote him at length. "As things now are," he says, "it is still more difficult and dangerous to discourse on nature, on account of the summaries and methods of the scholastic divines, who have, with all their might, reduced theology to order, and fashioned it into an art; and have, moreover, blended too much of the disputatious and thorny philosophy of Aristotle into the body of religion. And to this subject, though in a different respect, belong the labours of those who have ventured to deduce and confirm the truth of Christianity from the principles and authority of philosophers; celebrating with great pomp and solemnity the intermarriage of faith and sense, as a lawful union, and soothing the minds of men with a grateful variety of matter, while at the same time they have rashly and incongruously mingled things divine with human. In such medleys, moreover, of divinity and philosophy, only those things are admitted which are *now* received in philosophy, whilst things that are new, though better than the old, are almost entirely excluded. In fine, we perceive, that through the ignorance of certain divines, the passage to any philosophy, though ever so true, is almost blocked up. For some are foolishly alarmed lest a deeper inquiry into nature should transgress the bounds of sobriety; and they injudiciously wrest what is said in Scripture against those who pry into divine secrets, and apply it to the hidden things of nature, which are nowhere forbidden. Others, with greater craft, imagine, that if men are kept in ignorance, all things may be the more easily managed by dexterity of hand, and the *divining rod*, which they think is highly serviceable to religion: this, however, is nothing else than to aim at pleasing God by a lie! Others, again, dread the effect of example, lest any changes and movements in philosophy should fall at last on religion itself. Others are afraid lest, in the inquiry into nature, something should be found which may overturn religion, or at least undermine it, especially among the ignorant. These two latter kinds of fear appear to me altogether to savour of a grovelling wisdom; as though men, in their secret thoughts, were doubtful and distrustful of the stability of religion, and of the power of faith over the senses, and on this account apprehend danger to it from the search after truth in natural things. But whoever considers aright will acknowledge, that, next to the word of God, the most certain cure of superstition, and the best aliment of faith, is the knowledge of nature. Therefore philosophy is given to religion as her most faithful handmaid; the one manifesting the will, the other the power, of God: nor did he mistake who said, 'Ye err, not knowing the Scriptures, and the power of God,' thus inseparably blending and joining together the knowledge of his will, and the contemplation of his power. In the mean time, it is less to be wondered at that the increase of natural knowledge has been restrained, when religion, through the ignorance and incautious zeal of some, has been set in opposition to it."

 The *customs of learned societies* had also, up to the time of Lord Bacon, proved a serious hindrance to the advancement of knowledge.

In the schools and universities of Europe, scarcely any room was given for improvement, which was branded with the invidious name of innovation, an alarm that could not but prove fatal to the interests of pure truth. If any one dared to exercise the right of judging for himself, he could hope for no encouragement from others; and if he possessed sufficient independence of mind to stand alone, he must pay for his temerity with the loss of his fortune and his good name. All was rigidly confined within certain rules, and a given track was marked out as that in which every one must go without deviating either to the right or left. Little scope was afforded to the power of genius, which could hardly expand upwards beneath the overwhelming load of scholastic prejudice that weighed it down. Perhaps even in our own enlightened age, few of the universities of Europe are entirely emancipated from these shackles, as may be seen from the tendency there has always been to adhere to an *Aristotelian division* of the sciences, instead of following nature. "Unwilling as I am," says Mr. Stewart, at the close of his second volume on *The Philosophy of the Human Mind*, "to touch on a topic so hopeless as that of academical reform, I cannot dismiss this subject without remarking as a *fact*, which at some future period will figure in literary history, that two hundred years after the date of Bacon's philosophical works, the antiquated volume of study, originally prescribed in times of scholastic barbarism, should in so many universities be still suffered to stand in the way of improvements, recommended at once by the present state of the sciences, and by the order which nature follows in developing the intellectual faculties."

Lord Bacon also complains that in his time arduous endeavours at improvement were *not rewarded*. The power of advancing knowledge must proceed from the energies and exertions of superior minds, but the rewards which sweeten labour were in the hands of the vulgar and untutored. Even the boon of praise was, he observes, withheld, since the flights of elevated minds are above the reach of the crowd, and are disregarded through the force of prevailing prejudices.

Finally, science was kept in bondage by a kind of sullen *despair of success*, and the supposition of impossibility attaching to any new endeavours.—Such are the causes assigned in the *Novum Organum* as the principal sources of continued error and uncertainty in the pursuits of knowledge and science. ✧

#### VI. *Grounds of hope regarding the Advancement of Science.*

In that division of the work which we may call the *sixth* section, our author proceeds to treat of the *grounds of hope* for the further advancement of the sciences, and the general improvement of knowledge. Thus the *improvement in navigation* was to be regarded as the harbinger of good to the sciences, as enlarging the field of observation, and tending to increase our knowledge of nature.

The *very errors of past times* likewise, properly viewed, furnished a *hope of amendment*. Demosthenes endeavoured to rouse the Athenians from despondency to arm themselves manfully against Philip, their great enemy, by telling them that even their past misfortunes should be re-

garded as an omen of their future success, since they arose from their own negligence; whereas, if they had strenuously exerted themselves, and had still been unsuccessful, they might justly have despaired of the future: so, in the sciences, it would have been presumptuous to expect any great improvement, if we could have supposed mankind to have travelled so long in the proper road to truth without reaching it; but as they had evidently mistaken the way, hope of future success must be sought in first returning to the right path. The true method of science is ingeniously compared to the economy of the bee, which first gathers matter from the fields and gardens, and then digests and prepares it for use by her own native powers: "so," Lord Bacon observes, "the matter of philosophy must be carefully collected from nature, and then, after being digested and elaborated in the understanding, must be treasured up in the memory," in other words, additional hope of advancement in the sciences is to be found in the union of things that had been disjoined; that is, a strict *combination of experience with calculation and reasoning*. In all the schools of Greece, natural philosophy was blended with some foreign admixture, and was never studied purely and by itself. The Aristotelians corrupted it with a perversion of logic; the school of Plato mixed it up with an imaginative theology; the second school of Plato, Proclus, and others, made it to arise out of mathematics; whereas it is justly remarked that mathematics ought "not to generate or create natural philosophy, but only to terminate and perfect it;" that is, the facts and laws of nature must be sought independently, or in Nature herself—then mathematical reasoning may be applied to estimate and measure them, as has been exemplified in several of the tracts already before our readers. A return to the study of natural philosophy in a *pure and separate form*, was another source, therefore, of hope.

So also it might be expected that in future *some philosopher* might arise of sufficient independence of mind and lofty genius to free himself and the world from all the old and hackneyed theories: such a person, it is lamented, had not then appeared. How prophetic this was of the immortal Newton, who burst upon the world almost immediately after the death of Bacon, his forerunner—and how completely he emerged from the rude and undigested chaos of ancient fables into the light of truth, as those very comets whose laws he laid down issue from the dark abysses of space to their perihelion, the reader is sufficiently aware.

Much, very much, is also augured, as likely to arise from a better *history of nature* than had as yet been collected. The accounts which had been extant of the appearances and facts in nature had been chiefly founded on popular reports, indolent observations, and often on mere idle tales; and the whole had been so framed and turned as to strengthen the existing opinions in philosophy. Almost every thing in the history of nature was undefined and vague; much good must, therefore, needs have been expected to accrue from a more accurate register of facts and experiments. Bacon exhibits a rough sketch of such a history of nature in his *Sylva Sylvarum*, in his *Tables*, and in other parts of his works; the merits and defects of which we shall have occasion to notice hereafter.

Similar advantage was to be anticipated from a more enlarged stock

of *mechanical experience*, and a more enlightened attention to the most instructive facts of this kind. The workman is apt to think only of what is useful to his immediate work, and is not concerned about the discovery of truth: but, in order to improvement, recourse must be had to experiments, which, though useless, perhaps, as to direct and immediate profit, may be of great importance as to general information. 41

To this larger and more accurate stock of experience, Lord Bacon again insists, must be added the *method of induction*; or, as before explained, the pursuit of knowledge by reasoning from particulars to generals, from which every thing is to be hoped. In order to render this method as efficient as possible, it is strongly recommended accurately to commit to writing all the materials of philosophy, that is, the facts and observations on which general principles are to be founded; by no means trusting them, as had too often been done, to the memory, whose defects were usually supplied by a fanciful invention. To give this method still greater perfection, it is remarked that *tables* should be used for the clear arrangement of the facts, according to the nature of the subject; and from these tables *axioms*, or general principles, should be carefully formed, gradually rising from the less to the more general. It must be acknowledged, indeed, that many discoveries had been made accidentally by the alchemists, while seeking to make silver and gold; yet it is evident that more is to be expected in inventions from industry and method, whether we consider the number of such discoveries, the saving of time, or the adaptation of the things discovered to the supply of our wants. Men are more likely to find what they are carefully and intelligently in search of, than what is left merely to the operation of blind chance.

→ It was to be regarded as an additional ground of hope that *some things* already discovered were such as had previously never entered the mind of man; or which would, in all probability, have been despised as impossibilities, if any one had declared them likely to be found out. Gunpowder, though a destructive invention truly, may be taken as an instance. If, before this discovery had been made public, it had been declared that there was a method of battering down walls, and making an impression on the strongest fortifications at great distances, those who heard of it would instantly have supposed that this was effected by increasing the power of the common engines of war that were previously in use, as battering rams, and other machines of the same kind; which, of course, must be done by means of additional weights, wheels, and levers, and the various combinations of the mechanical powers; "but no one," says Bacon, "would have thought of a fiery wind which should blow with such a prodigious expansive violence, no obvious examples of such effects having been previously seen, except in the sublimer operations of nature, storms, thunder, and earthquakes, which it would not be supposed were imitable by art." Perhaps, to the ancients the expansive force of steam, now so extensively employed, would scarcely have appeared less wonderful, which, while it possesses such amazing power as to produce the most terrible effects when allowed to explode by being confined, is yet capable of being regulated at pleasure, and directed to an immense number of useful works with the greatest advantage. The invention of silk is mentioned as

another example. So, likewise, if, previously to the invention of the compass, it had been said that a certain instrument should be made known which in the open sea, and in the dead of night, when neither stars nor moon appeared, would exactly point out the quarters of the heavens, and that this instrument was nothing more than a metallic substance, which might easily be overlooked among the similar productions of the earth, this would have seemed almost incredible. Whence it is argued that many other things may yet remain in nature that might be of great service to mankind, which have little relation or analogy to the things already discovered.

Again, on the other hand, there are inventions of such a kind as easily to be *overlooked* for want of method, though they may almost, so to speak, stare men in the face. While some things, as gunpowder, silk, the compass, sugar, paper, may seem to depend on certain properties to be developed by Nature herself, yet other things, the art of printing, for instance, contains nothing that is not obvious and completely within human power; nevertheless, the world was for many ages destitute of this admirable invention, which is so intimately connected with the propagation of knowledge. Hence a ground of hope that science might be improved was to be drawn, not merely from the consideration of the unknown operations of nature hereafter to be discovered, but from the probable result of transferring, compounding, and variously applying those laws and operations which were already known.

Lord Bacon also derived encouragement from reflecting on the immense expenditure of time, genius, and property that had been bestowed on *pursuits of little or no use*, alluding, probably, to alchemy, the professed magic arts, astrology, etc.; since, if but a small portion of this labour should come to be bestowed in a proper manner, and on proper objects, great things might be expected to result: especially would such extensive and laborious *histories* of the *facts* and *operations* of nature as he recommended be the source of expectation. "A great and royal work truly this," he says, "and of much labour and expense."

As a further ground to suppose that human knowledge might be improved and increased to an extent of which some were inclined to despair, Lord Bacon introduces *his own example*, "not," he modestly says, "by way of ostentation, but because it may be useful." He argues, that if he himself—a man as much employed in civil affairs as any other of the age in which he lived, for he was Lord Chancellor of England at the time his *Novum Organum* was published;—if he, a man of but infirm health, has had the honour to lead the way unassisted by any coadjutor, in the new and untrodden path which he here attempts to point out to posterity; what may not be expected from men of leisure; from a union of labours; from a proper division of them, and from opportunities afforded by the succession of ages? He concludes his remarks on the grounds on which is founded the hope of advancing the sciences, by intimating that even were this expectation much less than he rightly deemed it to be, or, to use his own language, "although a much weaker and fainter breeze of hope should breathe from *this new continent*," or world of science, which he is endeavouring to point out;

yet it would be worth men's while, at all events, to make efforts to explore nature by the light of this new method: there was, at least, *a chance* of success resulting from their labour; whereas, to sit down in despondency, and to decline all enlightened exertions, could lead to nothing but ignorance and error, and was unworthy of the dignity of the human mind.

### VII. *Further Remarks preparatory to the Inductive Method.*

The last or seventh section into which this former part of the *Novum Organum* may be divided, is designed to give some further idea of the new method here proposed of interpreting nature. This, however, is done rather by way of guarding the reader against erroneous expectations than by developing the method itself which he reserves for the second part. "Having now levelled and polished the mirror," says our author in his figurative and expressive diction, "it remains that we set it in a right position, or, as it were, with a benevolent aspect towards the things we shall further propose. For to a new undertaking, not only a prepossession in favour of a rooted opinion is prejudicial, but a false notion and imagination of what is proposed to be done is equally so. We must, therefore, endeavour to convey a just and true idea of what we intend."

In order to prevent misapprehension, he again cautions his readers, as he had done at the outset of his work, against supposing that he aspired to be the founder of a *new sect* in philosophy, after the manner of the ancient Greeks. It was his aim, and it was an aim worthy of such a master-spirit, not to reign over men's opinions, but to conduct them into the temple of truth, from whose inmost sanctuaries they might obtain such a panoply as would enable them to extend the boundaries of man's power over nature, not in the noisy triumphs of a scholastic warfare; but in glorious victories over ignorance, prejudice, and error. Though he thus disclaims the idea of attempting to found a new sect, it must be allowed that he possesses that honour in the highest sense; for if we were, in the most general manner, to designate the philosophers of modern times, in contradistinction to the Aristotelians and Platonists of an earlier period, we should call them *Baconians*: Bacon may himself very justly be accounted the Father of the modern philosophy. He, however, contents himself here with aspiring, as he says, "only to sow the seeds of pure truth for posterity, and not to be wanting in his assistance to the first beginning of great undertakings."

Lord Bacon wishes his readers, in perusing his work, not to be prejudiced against the method he recommends, nor disappointed on finding that he has not made any very striking discoveries, which, indeed, he does not profess to have done; his design, in fact, being obviously of a more general nature. For though in the *Novum Organum*, and in his other works, indications and outlines of discovery are to be found, yet he considered that, up to his time, there was no sufficient collection of facts and appearances, to enable any one to enter with advantage on the genuine interpretation of nature. Still he did not wish to discourage any from employing their sagacity in attempting to make discoveries on the foundation of what was already known, or

from making use of his own tables and outlines of a history of nature, to this end; but his own great object, he repeats, was to prepare the way for future improvements, and not to neglect this his main design, for the sake of hasty and unseasonable diversions, like "*Atalanta*" in the fable, who lost the race by stopping to pick up the golden apple. "For we do not childishly affect golden fruit, but place every thing in the victory of art over nature."

He next cautions the reader against the effect which may be produced on his mind from meeting with some experiments in the *history* of nature, and *tables* of invention, which seem *not* well *verified*, or which may even be absolutely *false*. Such errors are to be expected to creep in at the dawn of the day of Science, and Lord Bacon was certainly by no means free from them. It must not, on account of a few such oversights, be suspected that the inventions he would point out are grounded on doubtful principles and erroneous foundations; and he argues that if any should be disgusted with some particular mistakes in his account of facts in nature, what must be thought of the remiss and negligent method that had hitherto been employed, and what of the philosophy and of the sciences that were built upon such "*quicksands*?"

Nor are men to turn away from the inductive method, or from the experiments it demands, as if in some cases it dwelt too much on what might seem *minute*, or *trite* and *vulgar*; since great mischief has arisen from many things having been spoken of as known and ascertained, of which, in fact, little was understood. Thus, in the philosophy that was prevalent, *gravity*, the *celestial motions*, *heat*, *cold*, *hardness*, *fluidity*, *density*, *animation*, *similarity*, *organisation*, were all the subjects of dogmatic assertion, while little that was satisfactory was said respecting them. Men, however, must condescend to attend to the commonest things if they would acquire knowledge, and to things displeasing to the senses. The design here is "*not*," he says, "to build a capital or erect a pyramid to the glory of man, but to found the temple of the universe in the human intellect." None are to suppose, what the vulgar are too ready to imagine, as well as all who were devoted to the existing philosophy, that the minutiae here laid down are tedious and subtil; they ought rather to consider that, for a time, efforts should be made to increase the materials of knowledge, to kindle the light by which nature may be examined, and that a too great impatience for immediate advantage should be checked. If any one should be inclined to disregard the cautions, principles, and axioms laid down in the method of induction, as needless subtilties, what would he say to the schoolmen, who are full of subtilties, '*without end as without fruit*?'

As an apology for what to many would appear a *bold* and *daring* attempt—that of rejecting all the sciences, and all the ancient masters in philosophy as with one stroke, without admitting the authority of any one single renowned name of antiquity, and trusting only to his own unaided strength—the author remarks that, were he disposed to act insincerely, it would not be difficult to persuade men that what he here attempts is but a revival of the most ancient method of Science, before nature was pompously ushered in with the "*flutes and trumpets of the Greeks*;" and, well acquainted as Lord Bacon was with the mythology of the ancients, it would have been easier perhaps for him

to have gained over the admirers of antiquity by this expedient, than to render palatable a system which presented no gaudy and alluring theories, and which came out entirely as a modern innovation. But with that astonishing degree of freedom from the shackles of prejudice, considering the time in which he lived, and that devotedness to natural truth for its own sake, which was so characteristic of this great philosopher, he disdains all such "stratagem and imposture," and relies exclusively on the evidence of things themselves. It is his object to place before the mind, not the mock models of the world which others had framed, of which the theories of Aristotle, Plato, and Epicurus, are specimens, but to present the world's true model as it exists in nature—to trace before the eyes of men the exact lines of truth.

Another objection, which it is supposed may be alleged, is, that, notwithstanding all the labour here employed to impress on mankind this new method of studying the Sciences, it will probably do no more than land us at length in *some one of those systems* of philosophy which prevailed among the ancients—that they, in the beginning of their investigations, procured a large stock of observations and experiments, and digested them into books and tables, as is here recommended, and from these sources extracted the matter of their theories; but thinking it needless to publish their notes and minute observations, those materials of their labours are now lost to us,—as architects, after a building is finished, take down the scaffolding and framework, and remove them out of sight. To this it is answered, that though it is difficult to suppose the ancients completed their works without some such collection of materials, yet, at all events, it is certain, from their writings, that their method of philosophizing was no other than flying hastily from some particular examples, to general conclusions; and if any new examples occurred, bearing an aspect hostile to their favourite ideas, they either contrived to make them seem to square with these, or else struck them out as exceptions, thus sacrificing every thing to their beloved theories. Now the very method here insisted on, Bacon argues, of rigidly adhering only to those principles which are common to all the particulars and examples, precludes the possibility of arriving at the same results with the ancients.

Nor can it be fairly charged upon this method of carefully attending to all the facts of the case before drawing the conclusion, that it leads to *scepticism*, since it is not the disposition to doubt, but the art of *doubting properly*, that is alone inculcated; and it is preferable to know something in a certain manner without supposing we know all, than to think we know all, and yet remain in actual ignorance of that which is most necessary to be known.

Lest it should be supposed, moreover, that the proposed plan only extended to the improvement of *natural* philosophy, more properly so called, he distinctly informs his readers that his design is of the most general kind possible. The method of induction is equally useful in all the sciences. It is alike applicable to *ethics, politics, the philosophy of the human mind, chemistry, botany*, and every other branch of knowledge.

As a further stimulus to a vigorous pursuit of science in this enlightened method, this first part of the *Novum Organum* closes with a

few additional reflections. It is urged that the discovery of *truth*, and noble inventions, holds the most *excellent* place among the actions of mankind. Antiquity, with all its errors, was perfectly alive to this sentiment, as is sufficiently evident by its attributing *divine* honours to the inventors of the arts, as to Prometheus, who is represented as being the giver of fire to mortals, and is celebrated in Æschylus as a deity—while it was usual to award *heroic* honours chiefly, to mere legislators and the founders of empires. The inventions of science, it is observed, “benefit mankind to the end of time ; while the advantages conferred by warriors and statesmen may last, in many cases, but for a few ages, and sometimes have their origin in tumults, and the most terrible desolations of war.” The effects of the invention of printing and of the mariner’s compass, for example, have been altogether prodigious : by these great instruments, navigation and commerce have been extended over the whole earth ; “divine and human learning,” to use the words of Milton, “have been raked out of the embers of forgotten tongues,” and the face of the world has been changed, in all its features, physical and moral.

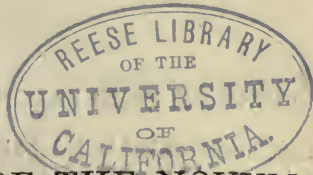
The design of promoting the advancement of the sciences is further pronounced a far *nobler* object of *ambition* than either *private* aggrandizement, or even *patriotism* itself. “The first,” says Lord Bacon, “is vulgar and degenerate ; the second, that is, the ambition of those who endeavour to raise their own country in the scale of nations, is more noble, but has not less of cupidity : but if any one should labour to restore and enlarge the power and dominion of the whole race of man over the universe of things—this kind of ambition, if so we may call it, is without doubt more wise and dignified than the rest. Now this power of man over things is entirely founded in arts and sciences.”

“Finally,” adds this illustrious author, “should any one object that the arts and sciences may be abused to *evil* purposes, as luxury and wickedness, let this sentiment be allowed to have no weight. The same objection would equally apply to all the most excellent things in the world—as genius, courage, strength, beauty, riches, and even light itself. Let the human race regain their dominion over nature, which belongs to them by the bounty of their Maker, and right reason and sound religion will direct the use.”

Thus did this vast genius point out to mankind the causes of those errors which so long effectually obstructed the paths of science ; thus did he encourage them to hope for a brighter æra, and give directions for the more successful pursuit, in future, of knowledge and truth. The second part of the *Novum Organum* contains a further development of the principles of the *Inductive Method*, with the author’s own examples of its use : and it will form the subject of another Treatise.

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See P. 25 → mark



# ACCOUNT OF THE NOVUM ORGANON.

## THE SECOND, AND CONCLUDING PART.

HOMO, NATURÆ MINISTER ET INTERPRES, TANTUM FACIT ET INTELLIGIT  
QUANTUM DE NATURÆ ORDINE RE VEL MENTE OBSERVAVERIT: NEC  
AMPLIUS SUI, AUT POTEST. — *Nov. Org.*

WE now proceed to give to our readers a view of the remaining part of the *Novum Organum*, as contained in the Second Book. Lord Bacon's design here is—to unfold his plan more particularly; and to convey some idea of the actual operation of that method of studying nature which he had the discernment to perceive was so absolutely essential to the advancement of all real science; and which he had the independence of mind to lay before the world, at a time when philosophers were generally devoted to hypotheses and fancies, and seemed but ill-disposed to an humble and laborious search after truth for its own sake, or to give encouragement to any one who should aspire to this arduous and honourable course.

We shall, as before, give the analysis of Bacon's doctrines, with such remarks and additional illustrations as may tend to throw light upon them. We are aware, indeed, that this part of his philosophical works has been regarded, and not unjustly, as somewhat laboured and obscure; but surely we must not forget the disadvantages under which he wrote; nor the wonderful revolution in science which he was the first instrument in effecting. It is certain, indeed, that, at the time when he flourished, the spirit of rational inquiry was not utterly unknown. In some few minds there was already a rising tendency to throw off the yoke of ancient systems, and some few instances were not wanting of the successful use of experiment; but no one had hitherto had the boldness and the genius, at once to make a formal attack on the general order of things as they existed in science, and to frame the grand and universal outline of another and a better plan. It was reserved for Bacon to proclaim aloud to the ear of Science, that she could only hope to be regenerated by first sacrificing herself on the altar of Truth; and that if ever she took an upward flight, she must pass a fiery ordeal, and rise like a phoenix from her own ashes.

Bacon, in this respect, stood alone; and if his *New Machine of the Sciences* appear, on more minute examination, to be somewhat cumbrous and defective, it was still a mighty effort to have devised such an instrument at all. If the genius of the new philosophy first issued from the thick darkness of the middle ages, wearing the garb and speaking the cramp language of the schools, this was perhaps an unavoidable consequence attaching to the period of its birth. The enlightened style of philosophy which now prevails, is certainly nothing more than the spirit of what Bacon taught, freed from all needless technicalities and incumbrances; and exercising, to the best advantage, its own proper energies. If Bacon did not perfectly exemplify his own rules of philosophizing, and if we sometimes see, as is certainly the case, the remains of ancient error in his con-

clusions, we should remember that he kindled the broader light we now act in, and which makes us discern clearly the imperfections of his own method. It is he who has enabled us to consider as ordinary and manifest truths, propositions utterly denied to his predecessors; and to complain of things as obscure, which to him were new, and were seen across the settled and distorting mist of error, and to us are clear only through the purer medium of his philosophy.

The second book of the *Novum Organon* may be divided into three parts; which comprise Aphorisms, or remarks on what is termed *the Discovery of Forms*; *Tables* in illustration of this discovery; and the *Doctrine of Instances*.

### Section I. *Of the Discovery of Forms, or Causes, in Nature.*

AFTER the primary object of ascertaining *facts*, or collecting the history of nature with regard to any subject of inquiry has been effected, the next aim proposed is, by comparing these different facts, to produce certain *changes* in matter; and to discover the ultimate *causes* on which its qualities depend. "The object and aim of human power," says Bacon, "is to produce a *new nature*, or natures on a given body; and the object and aim of human knowledge is to discover the *form* of a given nature; that is, its real difference; the nature which makes it what it is (*naturam naturantem*), or, the source whence it flows."

The scholastic word *form* here employed is borrowed from the Platonists, though with a meaning different from theirs. Plato and his followers adopted the notions before held by the Pythagoreans with respect to *forms*, *ideas*, and *essences*; and regarded the various configurations, or shapes of matter, as nothing more than copies of their *essences*, or *ideas*, as existing in the divine mind. Thus, for example, since the squares or circles actually drawn by the mathematician are never absolutely accurate, they supposed that their true *archetypes* or *patterns* are to be found subsisting by themselves in the mind of the Deity. Now Plato, and his school, maintained that this perfect *intellectual world* was discoverable by contemplation; and that while the visible creation is the object of *sense*, these ideas, or essences—the *forms* of things abstracted from matter,—are the proper objects of *science*. Bacon, in his work on the *Advancement of Learning*, while he pays the tribute of praise due to Plato's genius, condemns, as well he might, his mystical philosophy; and intimates that the *forms* which he himself proposes to discover are to be found *in* matter, and not *out of it*. In another passage in the *Novum Organon*, he expressly defines what he means by *forms*, in the following manner:—"When we speak of *forms*, we understand nothing more than those *laws* and *modes* of action which regulate and constitute any simple nature; such as heat; light; weight; in all kinds of matter susceptible of them: so that the *form* of heat, or the *form* of light, and the *law* of heat, or the *law* of light, are the same thing; nor do we ever lose sight of practice, and things as they are."

"The form of any nature" is, in another place, defined to be "such, that where it is, the given *nature* must infallibly be. The form is perpetually present when that nature is present; ascertains it universally, and accompanies it every where. Again, this form is such, that when

removed, the given nature infallibly vanishes: therefore the form is perpetually wanting where that nature is wanting; and thus confirms its presence or absence, and comes and goes with that nature alone."

In the language of Bacon, then, the *form* of any substance is its *essential nature*—the *form* of any quality is that which constitutes that quality. Thus, if the subject of investigation were the quality of *transparency* in any substance, the *form* of it is something of such a nature that, wherever it is present, there is transparency; and wherever there is transparency, that which is here scholastically termed the form, is likewise present. The *form*, he says, is the same thing, as regards our knowledge, with the *cause*; not limiting the meaning of this word to the *antecedents* or *circumstances* which immediately produce a succession of *events* or *changes* in matter, but including also the source from whence *permanent qualities* in body are derived. In short, the *discovery of forms* may be regarded as signifying the discovery of the *laws of nature* in general.

It may serve to facilitate our apprehension of Bacon's ideas, if we carry along with us the remark, which has not improperly been made, even by his greatest admirers—that he appears, from the language he sometimes employs with regard to forms, to have placed the ultimate aim of philosophy beyond what it is, in all probability, given to man to reach, however rigidly he may employ his faculties, according to the method here recommended. He seems to think that a knowledge of the *ultimate essences* of the qualities, and powers, or properties of matter, lie open to human scrutiny; that we can discover, for instance, wherein consists the *essence* or *nature* of *transparency*; of *cold*; of *heat*; of *colour*. Upwards of two centuries, however, have rolled away under the auspices of Bacon's system; and no one would as yet affirm that we have actually arrived at the boundary of nature, so as to have discovered the essence of matter itself, or of any one of its various modifications. We are still ignorant, strictly speaking, of the *causes* of the various operations of nature, after ages of laborious and scientific investigation; nor will the philosopher profess to have ascertained, with regard to any one series of these causes, or successive events and changes, that he has, beyond all possibility of doubt, at length arrived at the beginning of the series; that he has laid his finger on the ultimate link in the whole chain which is held by the hand of Omnipotence; and that he has traced the identical point at which these second causes merge, and are lost in the secret agency of the great First Cause of all; if indeed it be not more proper to consider all second causes as nothing more than so many constant actions of the Deity, regulated by his own laws.—In the case of *heat*, for instance,—by conducting inquiries in the spirit of the inductive method, many of the effects and properties of this powerful agent have been discovered; but its *form*, to use Bacon's language, or, in other words, *what heat is*, has not been ascertained. Perhaps a complete knowledge of its essence might, even if it could be known, conduce less to practical uses, than we may be ready to imagine: certain it is, however, that the question still remains undetermined, whether heat be a subtile fluid, and therefore of a *material* nature; or, as Bacon himself supposed, nothing more than a certain *motion* among the particles of bodies.

The same remark is applicable to the other great agents in nature,

"its form" i.e. its characteristic difference together with the cause of this difference. B 2

as *gravity, electricity, light, magnetism, elasticity*. Perhaps our notion of gravity is as simple as any, since its *one* property is the law of its decrease with the square of the distance; but whether this, and the rest have, or have not, any second causes beyond themselves, none presumes to say. While it would be unphilosophical to assert that more *can never* be known of these agents than what is already ascertained, it may be observed that, even should Bacon's aims, as to the discovery of forms, always prove to have been too high for mortals to fulfil, this is no disparagement whatever to his method, which still remains applicable to the investigation of causes, to the uttermost limits that can be reached by the perseverance and ingenuity of man.

"To the discovery of forms," proceeds Bacon, "belongs that of the *latent process* (*latens processus*); continued from the manifest producing cause of changes in bodies, and what is obvious to the senses, up to the giving of the form itself," that is, the ultimate law of nature in the particular case; or, at least, what appears to be that law: "there also," he adds, "belongs to it the discovery of the *secret structure*, (*latens schematismus*,) of bodies that are *quiescent* and exhibit no motion. The *latent process* we speak of does not here mean certain visible measures, or signs, or steps of procedure in bodies, but a perfect continued process, the greatest part of which escapes the sense. Thus, for example, in every generation and transformation of bodies, it comes to be inquired, what is lost, or flies off; what stays behind; what is added; what dilated; what contracted; what united; what separated; what continued; what cut off; what impels; what obstructs; what prevails; what yields, etc.: nor are these things only to be sought in the generation, or transformation of bodies; but, after the same manner, it comes to be inquired in all other alterations and motions, what precedes; what succeeds; what is quick; what slow; what gives motion; what governs it; and the like. But all these things remain unknown and untouched in the sciences, which are at present formed in a very gross and perfectly inadequate manner."

This *latent process*, undoubtedly a grand object of philosophical inquiry, to the farthest verge of human power, is, therefore, in modern language, the invisible and secret progress by which sensible changes are produced; and involves what has been termed the *law of continuity*; that is, the law by which quantities which change their bulk, or their places, do so, not abruptly, as in many cases may seem to us, but by passing through all the intermediate magnitudes, or distances, till the change be completed. In other words, all changes, however small, must be effected *in time*. We see this in innumerable operations of nature, such as the *planetary movements*; the phenomena of *accelerated velocity* in falling bodies; the *motion of light*, shown by the eclipses of Jupiter's satellites; in the progress of *disease*, in which there is a change of the structure of the parts. The late Professor Playfair remarks on this subject, "to know the relation between the time and the change effected, would be to have a perfect knowledge of the latent process;" the meaning, of course, is, if we could know all the *minutest* changes: for we may know, by experience, how much *time* it may take to effect a *given* change on matter, without knowing what *intermediate* changes may have led to the given one. In explanation of Bacon's doctrine, Mr. Playfair adds, "in the

firing of a cannon, for example, the succession of events during the short interval between the application of the match, and the explosion of the ball, constitute a latent process of a very remarkable and complicated nature, which, however, we can now trace with some degree of accuracy. In mechanical operations we can often follow this process more completely. When motion is communicated from any body to another, it is distributed through all the parts of that other, by a law quite beyond the reach of sense to perceive directly, but yet subject to investigation, and determined by a principle which, though late in being discovered, is now perfectly recognised. The applications of this mechanical principle are perhaps the instances in which a latent, and indeed a very recondite process has been most completely analysed." The allusion here is to the laws which regulate *percussion*, *collision*, and the *communication of motion* in bodies.

What Bacon terms the *latent schematism*, or structure of bodies, is that unseen shape and arrangement of their parts on which, it is obvious, so many of their properties must depend. The internal structure of plants, and the constitution of crystals, are instances; an inquiry into these is an inquiry into what is here quaintly termed the *latent schematism*; as also such an inquiry into *electricity*, *gravitation*, *magnetism*, etc., as would be directed towards the attempt to explain these facts, by any peculiar structure of bodies, or any arrangement of the particles of matter. "The inquiry," says Bacon, "and discovery of the concealed structure in bodies, is as much a new thing as the discovery of the latent process, and form; for men have hitherto trodden only in the outer courts of nature; and are not prepared to enter within. But no one can superinduce a new nature on a given body; or successfully and appositely change it into another body; unless he has first a competent knowledge of the body to be altered or transformed."

It must be confessed that Lord Bacon, emerging as he did from the prejudices of those ages in which philosophers pretended to account for almost everything, seems not only to have anticipated, as we have already observed, a greater perfection in human knowledge than it will probably ever attain, but also to have somewhat mistaken the way in which knowledge is to be converted to practical purposes. He supposes that if the *form*, or cause, or law, of any quality were known, we should be able, by inducing that "form" on any body, to communicate to it the said quality. It is not obvious, however, that even this knowledge would necessarily conduce to more simple and advantageous methods, than those of which the arts now furnish so many specimens. We are quite ignorant, for instance, on what *colour* in bodies precisely depends—what peculiar construction of surface it is, which makes a body reflect one particular species of light rather than another; yet we know how to communicate this quality from one substance to another. Would a knowledge of that concealed structure, on which this reflection depends, enable us to impart it to bodies more easily than we are able to do by immersing them in a liquid of a given colour?

Lord Bacon proceeds to make some remarks upon several of those *changes* in bodies, which he seems to have considered it within human power possibly to produce. He partly draws his illustrations from the pursuits of the alchemists; and makes some suppositions savouring to

us a little of paradox, though we cannot but discern his great sagacity, and admire his persevering diligence, amidst all the disadvantages under which he laboured. "We shall examine," says he, "what kind of rule, direction, or leading, a man would principally wish for, in order to superinduce an assigned nature upon a given body; as if any one should desire to superinduce upon silver the yellow colour of gold; and to increase its specific gravity; or to superinduce malleability upon glass; or vegetation upon a body not of the vegetable kind."

"The rule for the transmutation of bodies is of two kinds. The *first* regards a body as a certain collection, or combination of *simple natures (properties)*. Thus, for example, in gold, there meet together yellowness; a determinate gravity; malleability to a certain degree; fixedness in the fire; a particular manner of flowing in the fire; a determinate way of solution, etc., which are the simple natures (properties) in gold. For he who understands forms (causes), and the manner of superinducing this yellowness, gravity, ductility, fixedness, faculty of fusion, solution, etc., with their particular degrees, and proportions, will consider how to join them together in some body, so that a transmutation into gold shall follow."

"But the *second* kind of rule, which depends upon discovering the *latent process*, proceeds by *concrete bodies*, such as they are found in the ordinary course of nature: for example,—when inquiry is made from what origin, by what means, and in what procedure, gold, or any other metal, or stone, is generated from its first fluid matter, or rudiments, up to a perfect mineral. Or, again, by what process plants are generated, from the first concretions of their juices in the earth, or from the seed to a formed plant; together with the whole succession of motion, and the various and continued endeavours of nature. And this inquiry does not only regard the generation of bodies, but likewise other motions and works of nature: for example,—when inquiry is made into the whole series and continued actions of nutrition, from the first receiving of the aliment to a perfect assimilation; or, after the same manner, into the voluntary motions of animals, from the first impression of the imagination, and the continued efforts of the spirit, down to the bending and moving of the limbs; or again, in explaining the motion of the tongue, lips, and other organs, up to the formation of articulate sounds. For these things, also, have regard to concrete natures, or natures associate and organical.—And where mankind has no power of operating, but only of contemplating, yet the inquiry of the fact, or truth of the thing, belongs, no less than the knowledge of causes and relations, to the primary and universal axioms of simple natures: suppose, for example, the inquiry about the nature of spontaneous rotation, attraction, and many other natures; which are more common and familiar to us than the celestial bodies themselves. And let no one expect to determine the question whether the diurnal motion belongs to the heavens, or to the earth, unless he first understand the nature of spontaneous rotation."

The above passages, while they furnish an example of that acuteness and comprehension which so eminently distinguished their author, are not free from indications of his propensity to expect too much from human ingenuity, and to place the evidence of truth, in some respects, too high. His remark, for instance, with regard to the

“nature of *spontaneous rotation*,” whatever idea he attached to it, as belonging to the celestial motions, may account, in some measure, for his prejudice against the doctrine of *Copernicus*, which attributed the diurnal motion to the earth, and not to the heavens; and which had been published to the world many years before Bacon flourished. Indeed, a proneness to form boundless expectations as to what human power might effect; and, in the very infancy of practical science, to look for achievements higher than we can, even in its more advanced age, venture to hope for, is one of the most remarkable features in the elevated and daring genius of this great man.

Further, to explain his views with regard to the inquiry into the *latent structure* of bodies, he points out what he conceives to be some of the proper objects on which this minute investigation may be instituted, as iron and stone; the root, leaves, and flowers of plants; the flesh, blood, and bones of animals. *Distillation*, and other methods of separation, are instances, as collecting together the different homogeneous or similar particles of the same body. He here, however, acutely cautions the chemists of his day against supposing that all the natures (qualities) which may be exhibited in the separation of the parts of any substance, must have existed in the compound; new natures (properties) being often superinduced by heat, or some other method of resolving bodies; “for this structure,” he observes, “is a thing of great delicacy and subtilty, and may be rather confounded, than discovered and brought to light, by the operations of fire.” He adds, in his usual serious and imaginative style: “Bodies, therefore, are to be separated, not (merely) by fire, but by reason, and genuine induction; with the assistance of experiments; for we must go over from Vulcan to Minerva, if we would bring to light the real textures and structures of bodies.”

On the sanguine expectations and lofty aims which Lord Bacon indulged, with regard to what human industry and perseverance might effect, he proposes to found what he terms the “just division of philosophy, and the sciences,” into *metaphysics* and *physics*. “The inquiry of *forms*,” he says, “which, from the reason of the thing itself, and their own law, are eternal and immutable, may make *metaphysics*; and the inquiry into the efficient cause, the matter, the *latent process*, and the *latent structure*, may constitute *physics*, since these several (latter) particulars regard the ordinary course, and not the fundamental and eternal laws of nature.” Certain it is, that however just such a general division of all human knowledge might be in Bacon’s sense of it, could we realise his ideas and aims as to the *discovery of forms*, no progress has, as yet, been made towards the hopeful attainment of such a system of metaphysics; and probably the more secret operations of nature may for ever remain so shrouded from human penetration, as to render it impossible to say, in any one instance, that we have reached the goal, ascertained the very *first* in the series of second causes, and drawn the exact line between the subordinate operations of matter, and the immediate agency of the Infinite Spirit.—The following passages, on the “*raising of axioms, or principles from experience*,” are introductory to the tables in which Bacon has exemplified his own method of induction, in an inquiry into the “*form*” of *heat*; or, in what *heat* consists.

"The raising of axioms from experience is divided into three kinds of administrations or helps; 1. for the sense; 2. for the memory; and 3. for the reason."

(1.) "Therefore, a just and adequate natural and experimental history is to be procured, as the foundation of the whole thing; for we are not to fancy or imagine, but to discover what are the works and laws of nature."

(2.) "Such history must be digested and ranged in proper order; therefore tables and subservient chains of instances are to be formed in such manner, that the understanding may commodiously work upon them."

(3.) "And, though this were done, yet the understanding, left to itself, and its own spontaneous motion, is unequal to the work, and unfit to take upon it the raising of axioms, unless it be first regulated, strengthened, and guarded; therefore, in the third place, genuine and real induction must be used as the key of interpretation."

"The inquiry of *forms* proceeds in this manner. First, all the known instances, agreeing in the same nature, though in the most dissimilar subjects, are to be brought together, and placed before the understanding. And this collection is to be made historically, without any overhasty indulgence of speculation, or any great subtilty for the present. We will illustrate the thing by an example in the inquiry into the *form* of heat."

## Section II. *Of the Tables given in Illustration of the Inductive Method.*

The materials from which Lord Bacon designed that *tables* of this kind should be composed, for the future advancement of science, were such as he himself has sketched out in his book entitled, after the quaint fashion of the time, *Sylva Sylvarum*, or "A Natural History; in Ten Centuries;" each of the ten sections into which it is divided containing one hundred facts and experiments, relating to a great variety of subjects; the term *natural history* being here used in a very extensive sense, to signify a record of observations on nature in general.

Such a history of facts as that from which tables should be drawn, was to contain an account of the subject under examination, in all the varieties and modifications of which the appearances belonging to it were susceptible. Not only were these facts in nature to be included in it, which offer themselves at once, and of their own accord, to the senses, but also all those experiments which might be instituted for the discovery of new facts relating to the same inquiry. These facts and experiments were to be ascertained with the greatest care; faithfully and simply stated, without mixing up any theory with the narration of them; and distinctly arranged. If any thing rested on doubtful evidence, this was not to be altogether excluded from the history of the subject, but to be noted down as uncertain, together with the reasons for so regarding it; and it was not to be employed as evidence in the discovery of *forms*, or ultimate causes, till rendered more probable by other facts, on which there rested nothing doubtful. In short, this *history* of nature was to be, as much as possible, a copy of nature herself, both as regarded obvious facts, and actual experiments; for, in experiments, as Bacon observes, "man does nothing more than bring things nearer to one another, or carry them farther off; the rest is performed

by nature." This remark has its exemplification in such operations as the firing of a pistol, the discharge of an electrical jar, and in all the experiments of chemistry, in which the art of man does no more than commence the process by applying the spark to the gunpowder, or by causing the connection between the inside and outside of the jar to be produced, or the electric circle to be completed; or by bringing the chemical agents into contact with each other; the rest is done by nature herself.

It must be acknowledged that a single glance into the *Sylva Sylvarum* will convince the reader that it is far from answering to the standard which its great author sets up for regulating the collection of the materials of scientific inquiry. In his "Experiment Solitary touching the commixture of flame and air, and the great force thereof," he says, "As for living creatures, it is certain their *vital spirits* are a substance compounded of an airy and flamy matter. It is no marvel that a small quantity of spirits in the cells of the brain, and canals of the sinews, should be able to move the whole body, which is of so great mass; such is the force of these two natures, air and flame, when they incorporate." It is unnecessary to adduce other specimens, many of which are to be found, as fanciful in matter, as vague in statement, and as gratuitous in evidence; in a word, exhibiting as complete a departure from the severity of the inductive method. Yet, amidst this indigested mass of facts and fancies, it is impossible not to discern the unwearied diligence, the acuteness, the boundless curiosity, and insatiable appetite for knowledge, which Bacon possessed. It is interesting to see the energies of such a mind grappling with the difficulties which inevitably surrounded it; eager for liberty, beneath the shackles that cramped its exertions; panting for the pure air of truth, amidst those oppressive mists of error which beset it on all sides; and more readily taking up with error, from its very impatience for truth. Bacon's faults as a practical natural philosopher, the occasional credulity and love of theory which he manifests, are only the more remarkable from his having so admirably descanted on those very errors by way of speculation. To free himself from the actual dominion of error in natural science, even though he had such lofty general conceptions of truth, was perhaps impossible in his situation. The morning star of nature is, in the language of Milton, "last in the train of night," though it belongs "better to the dawn;" and the sun himself cannot shake off the mists that attend his rising—time is needed to dispel them: Bacon was the first grand luminary of science, and it was no wonder that a portion of the darkness of the middle ages should still cling around him.

Nor was he himself unaware of the imperfection of those crude and recent materials from which, for want of collections of facts sufficiently accurate and long-established, he was obliged to deduce his tables. Perhaps, what he chiefly intended was a rough sketch of the history of nature, leaving it to posterity to follow out his plan with greater accuracy, and with all the advantages of time. This appears, indeed, from the caution which he gives his readers, quoted in our former Treatise on this work, not to reject his method itself, because some experiments and facts may not be so well verified as might be wished; or others even absolutely false. The same may be gathered from the

following remarkable passage in the Preface to the *Sylva Sylvarum*, by Dr. Rawley, who was Lord Bacon's chaplain. "I have heard his Lordship often say, that if he should have served the glory of his own name, he had been better not to have published this Natural History; but that he resolved to prefer the good of man, and that which might best secure it, before any thing that might have relation to himself. And, in this behalf, I have heard his Lordship speak complainingly, that his Lordship, who thinketh he deserveth to be an architect in this building, should be forced to be a workman and a labourer, and to dig the clay and burn the brick; and to gather the straw and stubble over all the fields to burn the bricks withal. For he knoweth that except he do it, nothing will be done; men are so set to despise the means of their own good."

Lord Bacon formally *exemplifies* his method of induction in this part of the *Novum Organon*, on the subject of *heat*—his object being to inquire, what is its *form* or *nature*? In order to institute this inquiry, he arranges the facts and experiments he was acquainted with relating to it, in *five different tables*. These tables, while they partake of all the imperfections found in the *Sylva Sylvarum*, can scarcely be denied the praise, as Professor Playfair remarks, of being "extremely judicious," while the whole disquisition, as the same excellent judge observes, "is highly interesting."

*Tab. I.*—The *first* table contains instances in which heat is found and is termed, by the author, the "*Affirmative Table*;" or "*Instances that agree in possessing the nature of heat*;" and here are enumerated the sun's rays, direct and reflected; fiery meteors; lightning; flame; ignited matter; hot springs, and heated fluids in general; sultry seasons; subterraneous air; the coverings of animals; all bodies exposed to the action of fire; sparks struck out by collision; matter in a state of friction, as the wheels of carriages; green and moist plants when pressed together, as hay; slaked lime; iron in a state of effervescence with acids; the bodies of animals; herbs that are hot to the taste, as cresses: vinegar also is added, as applied to the flesh; and even intense cold producing a burning sensation.

*Tab. II.*—The *second* table which Bacon proposes in pursuit of his method, is *negative*; containing a list of *things in which heat is not found*: but, for the sake of brevity, the examples here introduced are to be only of those things which have a *near relation and resemblance* to the things mentioned in the first table, *heat alone excepted*, in which they are, to all sense, wanting. Thus, the first example of the "*instances agreeing in possessing heat*," were the *sun's rays*; and the parallel *negative* instance, or the first mentioned in the *second* table, are the *rays of the moon*, of *stars*, and of *comets*, since these are all luminous, though less so than the rays of the sun, but are *without heat*. In like manner, every instance in which heat *exists* in the things enumerated in the *first* table, is to have one or more parallel instances in the *second*, in which heat is *wanting*; though the substances in both the tables seem nearly related to each other.

*Tab. III.*—The *third* table consists of a *comparison of the degrees of heat* found in different substances. The things first to be considered are such as discover no heat whatever to the touch, but seem only to have, says Bacon, "a certain *potential heat*, or a *disposition and prepara-*

tion towards actual heat." Quicklime, green plants, acrid vegetables, etc., are mentioned as examples. The first degree of heat sensible to the touch, he considers to be that of *animals*; and inquiry is to be made respecting the comparative heat of the different kinds of animals, and of different parts of the same animals; and the causes by which animal heat is increased. The degrees of heat in various kinds of *flame* are also to be observed; as in the flame of alcohol; of porous vegetables; of wood; of unctuous substances, as oil and tallow; of pitch and resin; of sulphur; of gunpowder; of imperfect metals, as regulus of antimony; and of lightning. Also the degrees of heat in *ignited* bodies, as in tinder, coal, and metals. The thermometer (*vitrum calendare*), which was just come into use when Bacon wrote, is mentioned as showing the extreme aptitude of the common air to receive and communicate heat; being affected by the slightest change of temperature. Next to the air, those bodies were imagined to be most sensible of heat which had been newly changed and condensed by cold, as snow and ice; then is mentioned conjecturally quicksilver; next unctuous bodies, as oil and butter; afterwards wood; water; and lastly, stones and metals, as not heating so easily, though they retain their heat a long time.

This table, while it discovers, like the rest, the exhaustive genius peculiar to its author, and the enlarged general views which he took of the subject of inquiry, possesses the same defects as it regards accuracy in the facts; and occasionally the same insensible tendency to theorize. It appears singular enough, for instance, to us, who know the property which oxygen has of sustaining combustion, that the increase of heat should be accounted for mechanically thus: "Motion increases heat, as appears by bellows and blow-pipes;" and that after a description of the thermometer, and the sensibility of the air in respect of heat and cold, it should be added, "but we conceive that the spirit of animals has a still more exquisite sense of heat and cold, unless it be obstructed and blunted by the grosser matter of their bodies." Yet it is here remarked—"How unprovided we are in natural and experimental history, may be easily observed from hence; that in the preceding tables we are frequently obliged to direct experiments and further inquiry into particulars; and that, instead of approved history, and such instances as may be depended upon, we are sometimes driven to insert *traditions*, and *stories*, though we do this with a manifest doubting of their truth and authority."

These *three tables*, containing a great number of such *positive*, *negative*, and *comparative* examples on the subject of heat as we have quoted, are designed, Lord Bacon says, to "present a view of instances to the understanding." And when this view is procured, the business of *induction* is to be put in practice. "For, upon a particular and general view of all the instances, some quality or property is to be discovered, on which the *nature* of the thing in question depends, and which may continually be present or absent, and always increase and decrease with that nature; and limit the more common nature. God, the giver and Creator of *forms*, doubtless knows them by immediate affirmation, and at the first glance; and so, perhaps, may angelic intelligences; but this is certainly beyond the power of man, to whom it is given to proceed, first, by *negatives* only, and after a perfect exclu-

sion by *affirmatives*. We must therefore make resolution and separation of nature, not by fire, but by the mind, which is, as it were, the divine fire. And thus the *first* work of genuine induction in the *discovery of forms*, is to throw out, or exclude, such particular *natures* as are not found in any instance where the given nature is present ; or such as are found in any instance where that nature is absent ; and again, such as are found to increase in any instance when the given nature decreases ; or to decrease when that nature increases. And then, after this rejection and exclusion is duly made, the affirmative, solid, true, and well-defined form will remain as the result of the operation, whilst the volatile opinions go off, as it were, in fume. And if any one shall think that our forms have somewhat abstracted in them, because they appear to mix, and join together things that are heterogeneous, as the heat of the celestial bodies, and the heat of fire ; the fixed redness of a rose, and the apparent redness of the rainbow, or the opal ; death by drowning, and death by burning, stabbing, the apoplexy, consumption, etc., which, though very dissimilar, we make to agree in the nature of heat, redness, death, etc., he must remember that his own understanding is held and detained by custom, things in the gross, and opinions. For it is certain that the things above-mentioned, however heterogeneous and foreign they may seem, agree in the *form* or *law* that ordains heat, redness, and death."

The first step, therefore, according to Bacon, in an inquiry into the *form* or *cause* of any thing by induction, is to consider what things are to be excluded from the number of *possible* forms or causes. This exclusion contracts the field of inquiry, and brings the true explanation of the case more within reach. Thus, suppose the subject in question be, to use the language of our author, the *form of transparency* ; or in other words, the quality which is the *cause* of transparency in bodies : now since the *diamond* is transparent, we immediately exclude *fluidity*, and *porosity*, or *rarity* ; because the diamond is a very solid and dense substance : that is, a body may be transparent, without being either fluid or light, compared with other bodies ; neither fluidity nor lightness, then, are the form or cause of transparency.

*Tab. IV.*—Bacon's *fourth table*, accordingly, proposes to exhibit " an example of this exclusion, or rejection of natures from the form of heat ; that is, a rejection of those things as the *causes* of heat, in which it evidently cannot consist. Thus, as both the sun's rays and common fire are hot, he excludes both " *terrestrial and celestial nature.*" *Light* and *splendour* are also rejected as essential to heat, because water, air, and solid bodies will receive or conduct heat without being ignited ; and, on the contrary, the rays of the moon and stars present light without any sensible heat ; also because ignited iron is less lucid, but hotter than the flame of alcohol. Again, *tenuity*, or a certain lightness of substance, is to be excluded as the cause of heat, because gold, which is very dense, can be ignited ; while the air, which is generally cool, is thin and subtile. *Expansive motion* is also to be rejected, Bacon says, " because ignited iron enlarges not in bulk, but remains of the same dimension ;" this, however, is contrary to a well-known fact in the economy of heat.—As bodies are warmed without *destruction of the parts*, this destruction is to be excluded. Other things also are to be rejected, " for our tables," says the author, " are not designed as perfect, but only as examples."

Hence, it is added, at the end of this table, "The business of exclusion lays the foundation for a genuine induction, which, however, is not perfected till it terminates in the affirmative; but an exclusion is by no means perfect at first, nor can it possibly be so; for exclusion, as we plainly see, is the rejection of *simple natures*; and if we have hitherto no just and true notion of simple nature, how can the business of exclusion be rectified? But some of the above-mentioned notions, as those of *elementary* (or terrestrial) nature, *celestial* nature, and *tenuity*, are vague and ill-defined. Wherefore we must proceed to greater helps for the mind. And yet we judge it useful to allow the understanding to apply itself and attempt the business of interpreting nature in the affirmative, on the strength of the instances contained in these tables, and such as may be otherwise procured. And this kind of attempt we call a *permission of the understanding*, the rudiments of interpretation, or the first vintage of inquiry."

*Tab. V.*—The next, which is the *fifth table* and the last, is accordingly quaintly entitled, "*The first Vintage concerning the Form of Heat*;" that is, a rough and general specimen of a conclusion derived from the foregoing investigation. Bacon concludes, here, that from an examination of all the instances, "separately and collectively, *the nature whose limitation is heat, appears to be motion*," which he attempts to prove from the view he took of the facts. He adds, "what we have thus said of motion is to be understood of it as of a *genus*, with regard to heat, and not as if heat generated motion, or motion generated heat, though this may be true in some cases; but the meaning is, that *heat itself*, or the very existence of heat, *is motion*, and nothing else, though motion limited by differences, which we shall presently subjoin."

He next points out these "*differences*," as he terms them; that is, he endeavours to discover what *kind* of motion this is of which he speaks. He *first* argues that it is *expansive*, whereby a body dilates itself; which, however, is hardly consistent with his observation on ignited iron in the fourth table. The *second* "difference," or quality of the motion is, that heat is an expansive motion toward the circumference, and which at the same time rises upwards. "The *third* difference," he says, "is that this motion is expansive in the lesser particles of a body;" and "the *fourth* difference is, that the motion in which heat consists is rapid." All this he attempts to prove, and concludes thus: "Let this serve for what we call the first vintage, or an attempt towards interpreting the form of heat, which the understanding makes, as we said, by way of permission. The fruit of this first vintage is in short: Heat is an expansive, bridled motion, struggling in the small particles of bodies. But this expansion is modified; so that, while it spreads in circumference, it has a greater tendency upwards. It is also vigorous and active. And as to practice, if, in any natural body, a motion can be excited which shall dilate or expand, and again recoil or turn back upon itself, so as that the dilatation shall not proceed equally, but partly prevail, and partly be checked, any man may doubtless produce heat. And this may serve as an example of our method of investigating Forms."

Notwithstanding the imperfection of these tables as to their detail, the want of accuracy in the experiments, the crudeness, and the apparently gratuitous style of Bacon's conclusions, amidst the laboured appear-

ance of the whole, it is worthy of remark that his hypothesis on the nature of heat is the very same as one of those which still, at the distance of nearly two centuries, divide the opinions of philosophers. The more direct and elegant manner in which the moderns have employed his inductive method, has not, in the very instance which he first chose as an example of it, enabled them to go one single step beyond him. It is still a question, whether heat be really *matter*—a subtile fluid capable of diffusing itself in bodies; or any thing more than a *motion*, vibration, or rotation, excited among their particles. All the experiments that have been made up to the present time, have not availed to set the question at rest; and the greater part of the facts relating to heat may be explained equally well on either of the two suppositions.

### SECTION III.—*Of the Doctrine of Instances, or Facts, as regards the Discovery of Forms.*

It is obvious that *all* facts, however well authenticated they may be, are not of equal importance in the discoveries of science. Some facts are so like others, that it may be quite unnecessary to notice them. Some exhibit the subject of inquiry in its most simple state; others present it with a combination of circumstances. In some cases the thing sought appears in its highest degree; in others in its lowest. In medicine, for instance, a disease sometimes presents itself in its purest form, and most regular progress; at other times it is involved in a variety of other symptoms that do not belong to it. Hence Lord Bacon proposes to consider what he calls *Prerogativæ Instantiarum*, *Prerogative Instances*; or the *comparative value of facts* as means of discovery, or instruments of finding truth.

The design here is to show what are the *most important* and essential *particulars* in every inquiry; or what instances in the operations of nature are chiefly to be sought for, and attended to, in order to discover the laws of nature in general, to whatever extent man may be able to ascertain them. The conclusion on the subject of heat being only to be regarded as an *example*, and not as a perfectly established truth, Bacon retraces, in a manner, his own steps, and proceeds to treat, generally, and more accurately, of the way of procuring a proper collection of such facts, experiments, and observations, as are best fitted to constitute *affirmative*, *negative*, and *comparative* tables, like those we have described; and this in order, ultimately, to shorten the inquiry, and to render it more rigid.

We shall now give our readers an outline of these "*Prerogative Instances*;" or those cases which have a chief claim to be noticed in the attempt to interpret the laws of nature; retaining the terms which Bacon figuratively applies to them. He divides them into three classes, which he denominates those which address themselves to the *understanding*; those which assist the *senses*; and those which conduce to *practice*.

#### I. *Instances addressing themselves to the Understanding.*

1. The first are the *Instantiæ Solitariae*; *solitary instances*. These are divided into *two* classes.—The *first* are those examples in which the *same* "nature," or quality, exists in different bodies, which have

*nothing* in common but that quality; that is, the bodies differ in all things but in this one. The conclusions that can be entertained in this case, respecting the *form* or cause of this quality, are limited, inasmuch as they involve none of the things in which the bodies differ, but only that in which they all agree. Crystals, prisms of glass, and dew-drops, are *instantiæ solitariæ*, because they exhibit colour, in some situations, while they have nothing in common with stones, metals, wood, flowers, etc., whose colours are fixed, excepting the colour itself. Hence Bacon infers that colour is, in the first substances, that is, in crystals, etc., simply a modification of the rays of light, produced by the different degrees of *incidence*, or the angles which light makes in falling on them; and in the latter case, as in stones and metals, he concludes that colour depends on the texture and structure of the surface. It was by these examples that Newton afterwards discovered the composition of light.

The *second* class of *solitary instances* are the reverse of the former. They are those cases in which the "nature" or quality, which is the subject of inquiry, *differs* in two bodies which are in all other respects the same; that is, the bodies here agree in all things but this one. The *form* or cause here, therefore, cannot exist in any of the general things in which the bodies agree. The veins of black, and of white, in marble, and the variety of colours in flowers, are adduced as examples; where the substances agree, almost in everything but in colour. Bacon here again concludes that permanent colours depend chiefly on the texture of the surfaces of bodies, and very little on their internal and essential properties.

2. *Instantiæ Migrantes*, or *travelling instances*, are those in which one quantity is lost, and another is produced; or, in which the nature or quality inquired into exhibits changes and degrees, passing from less to greater, or from greater to less; in the one case approaching its *maximum*, or greatest state, in the other tending to extinction altogether. Let the inquiry be into the cause of *whiteness*, in bodies that are of this colour. *Glass* and *water* are mentioned as examples. Glass, when whole, is without colour; but, when powdered, becomes *white*: so water in its natural state is colourless, but is white when in the state of *foam*. Both these substances pass from a state of transparency to an opaque state. "It is manifest," says Bacon, "that the form (cause) of whiteness travels or is conveyed over by pounding the glass, and agitating the water; nothing, however, is here found but a bare comminution of the parts, together with the interposition of the air; and whiteness is exhibited by a different refraction of the rays of light." Metals becoming *fluid* by heat, and again *solid* by its abstraction, might be added as another example. Also the *shells* which are often found perfect in limestone, and by degrees become lost in the finer marbles, till they are no longer discerned. The mineral kingdom presents *this* kind of instances in the greatest abundance, and such facts are, perhaps, nowhere of greater importance in practice. The barometer also furnishes an instance of this *progressive* kind; for on going to the top of a mountain the mercury sinks, which it ought to do, if it be the weight of the atmosphere that supports it, because the column of the atmosphere is now shorter.

3. Next come the *Instantiæ Ostensivæ*, *glaring instances*; which our

author also terms *eluscentiæ*, and *predominantes*, or instances which shew the *nature* or quality in its highest power and degree, and freed from the obstructions which usually counteract it. The nature which is the subject of inquiry is here, as is represented, fully displayed, either by the absence of such obstructions to it, or by its prevailing over them by its own energy. The *thermometer* is judiciously chosen as an example; this instrument very obviously shewing the expansive force of heat in its operation on air. Perhaps, Lord Bacon is not so happy in adducing *quicksilver*, on account of its fluidity, as a *glaring* instance leading towards the discovery of what *gravity* is; for gold, which is heavier than quicksilver, becomes fluid also by the application of heat; and quicksilver is solid at a certain temperature.

Professor Playfair adduces as an example of this class, the shells, corals, and other marine exuvîæ, or their impressions, found imbedded in solid rocks, and on high mountains, as decisively proving the original formation of such land under the sea.

4. The *Instantiæ Clandestiænæ*, or *obscure* instances, may be considered as opposed to the last. Bacon has also fancifully called them *Instantiæ Crepusculi*, *twilight* instances. These are the cases in which some quality or power is just beginning to manifest itself, and is in its weakest and most imperfect state. These he regards as peculiarly important in attempts at generalisation. He mentions an example with reference to the nature of *solidity*, exhibited in a low degree in a fluid, when water, blown into a bubble, assumes a kind of consistent skin, and may be thrown in this form to a considerable distance; and he infers, from such cases, that fluidity and solidity are only relative ideas, and that bodies have what he terms "a real appetite to avoid discontinuation." Water suspended in *capillary*, or very small tubes, is another illustration. This effect may be viewed when at its *minimum*; or in the least degree, that is, when the tube is increased in its bore. The column of water now becomes a slender ring, going all round the vessel. As this ring must be formed by the attraction of the sides, and of the part directly above the water, there can be no doubt that the capillary suspension arises, in part at least, from the same cause.

5. In the fifth place, are noticed the *Instantiæ Manipulares*, or *collective* instances; that is, general facts, comprehending a number of particular cases; tending to carry us to a certain extent, in the discovery of *causes*, and assisting in the attempt towards a further generalisation.

The *laws of Kepler*, not mentioned by Bacon, though discovered before he wrote, are a case in point. These laws, which aided Newton in detecting the principle of *gravitation*, are three general truths or facts in astronomy; each of which holds with regard to every planet. These laws are, that the planets all move in oval orbits round the sun, placed in the common focus; that a line, supposed to be drawn from this focus, or point in the ellipse, to any planet, passes over equal spaces in equal times; and that the squares of the times of revolution round the sun are always as the cubes of the mean distances from him. Each of these laws was discovered, after vast labour and research, and by comparing together an immense number of observations. In such collective instances astronomy is fertile. A planet is seen in the heavens; by long and diligent attention, it is

found to move in a certain direction, with a certain velocity, and to perform its revolution in a certain time. Hence the periodic time, or the year of every planet is a collective fact,—a fact resulting from numerous observations.

Bacon's example of this kind of instances is taken from *memory*, the nature of which is supposed to be the subject of inquiry. Collective instances, tending to conduct us some way in the investigation, are, he says, such facts as these; namely, that *order*, *artificial associations* of ideas, and *verse*, aid the memory; also whatever appeals to the *senses*, or the *passions*, so as strongly to excite them; again whatever is presented to a mind that is *free* and unoccupied, as is the case with children; what is noticed for the *first* time; and what we make an *effort* to retain—these things are usually best remembered. This instance may serve to show the comprehensiveness of Bacon's design, which was to prescribe rules for all kinds of investigations, whether relating more strictly to natural philosophy, or, as here, to intellectual science; indeed, it was in his ideas relative to the conduct of the understanding in its pursuit of truth that he chiefly excelled.

6. *Instantiæ Conformes*, or instances that are *parallel*, or analogous, are facts which resemble each other in some particulars, while in all the rest they are very different. Optical instruments and the eye; the structure of the ear, and of caverns that yield an echo, are mentioned as examples. Also the fins of fish; the feet of quadrupeds; and the wings of birds.

It was the obvious analogy between the eye and the telescope, that led to the formation of *achromatic*, or colourless glasses: the means of which invention were pointed out by observing the different refractive powers of the *humours* or lenses of the eye, which prevent the field of view from being coloured round its edges; this was successfully imitated in the telescope. On the other hand, *art* has, by a similar instance of conformity, been able to point out what takes place in nature: the experiment of the *camera obscura* led to the discovery of the image on the *retina* of the eye, by suggesting the probability of it.—Sir James Hall's experiments may be added; showing that the presence of calcareous spar, in *trap* rocks, and its absence in *lava*, may arise from the degree of compression under which the fusion of the former took place. Basalt and other trap rocks have a structure so exactly similar to the lava of volcanoes, that it could scarcely be doubted that their origin was equally derived from the agency of fire; hence the successful inquiry into the cause of the difference.—The valves in the blood-vessels of the human body resembled those used in hydraulic machines for preventing the return of the water; hence Harvey took the hint which led him to the discovery of the circulation of the blood.

7. Next are mentioned what are termed *Instantiæ Monodicæ*, *singular*, or irregular facts; such as are “out of course;” or are remarkably distinguished from all other instances of the class to which they belong. Examples are, the sun and moon among heavenly bodies; the magnet among stones; mercury among metals; the elephant among quadrupeds. To these of Lord Bacon may be added such instances as the newly-discovered planets, which do not move in the zodiac, and are of a much smaller size than the others; also Saturn's

ring, which is the only case we know of the kind.—Those stones called *aërolites* also, which have sometimes fallen from the heavens, may be noted as presenting a singular class of well-authenticated facts, not yet satisfactorily explained.

8. Almost the same with the last, but mentioned as distinct by Bacon, are the *Instantiæ Deviantes*, or *deviating* instances; “that is,” he remarks, “errors of nature; things monstrous and uncommon, where nature turns aside from her ordinary course. These errors of nature differ from the *singular* instances, which are miracles in species; while these errors are miracles in individuals. And here the *latent process* that leads to the deviation is to be inquired into.”

Examples of these are, he adds, “all prodigious and monstrous births, and productions of nature; and of all things new, extraordinary, or uncommon in the universe. And here such things are to be suspected as the prodigies of Livy; and those no less which are found in the writers on natural magic, alchemy, etc., who are the professed admirers and lovers of the fabulous.”

9. *Instantiæ Limitaneæ*, or *limiting* instances, are also very near akin to the *singular*. They are those which exhibit, as it were, a combination of *two* different kinds in the same individual: the bat and the flying fish are examples; also the mole; and all combinations of different species; among these none are more remarkable than the strange quadrupeds lately discovered in New Holland, partaking of the structure both of birds and beasts, and called, by naturalists, the *Ornithorhynchus Histrix* and *Paradoxus*.

10. The next place is assigned to what are called the *Instantiæ Potestatis*, instances of *power*; by which are meant the most remarkable productions of human ingenuity; or, as they are described, “the most noble and perfect works, and such as may be called the masterpieces in every art.” Here are introduced the destructive inventions of gunpowder and ordnance; the manufacture of silk; also that of paper, on which he comments with great admiration, as very singular in its texture among the productions of art. He notices also glass, porcelain, and enamel; and adds that contrivances of “dexterity, delusion, and diversion,” are not wholly to be rejected from the enumeration, nor even “things magical and superstitious; charms; the supposed sympathy of spirits,” etc.; because, under the falsehood of these things, the true operations of nature may oftentimes be concealed.

Of these instances, it would be endless to adduce the examples which might be furnished by the modern improvements in art and science; the *steam-engine* alone might suffice, as connected with a world of inventions, each of which would have appeared to our indefatigable author a “masterpiece of art;” witness only one of the applications of it, namely, to the working of vessels on water. But in the line with gunpowder, or rather in advantageous contrast to it, may well be placed the safety-lamp,—aptly termed by Professor Playfair, “the most valuable present that science ever made to art.”

11. *Instantiæ Comitatus*, atque *Hostiles*, or instances of *accompaniment* and *separation*, are those in which certain qualities, or properties, always accompany each other, and the reverse.

Of the first kind are *flame* and *heat*; that is, all flame possesses heat, while in air, stones, metals, heat is merely accidental, or may

\* with which Icterus even furnished the brain

come and go. So also, excepting a very few particular cases, *heat* and *expansion* are an instance of this class; heat being accompanied with an increase of the substance in which it resides. *Body* and *gravity* may also be adduced; for whatever is impenetrable and has *inertia*, that is, everything of which we can certainly say, it is *matter*, possesses also weight, more or less.

The *hostile* instances, or those of *separation*, are opposed to the former; that is, the quality which is the subject of inquiry is always absent from them. Thus, in the case of solidity: air, and elastic fluids in general, cannot, so far as we know, assume a solid form; they are never exhibited in this state, although the discoveries of Mr. Faraday have limited the number of permanently elastic fluids by condensing, through pressure, many which were before thought incondensable. So, in the case of *transparency*: this, in solid bodies, is not found joined with malleability.

12. *Instantiæ Subjunctivæ*, *subjunctive* instances, or those which may be subjoined to the last, as seeming nearest to approach the exceptions to them. "As for example," says Bacon, "the mildest and softest flames, or such as burn the least; and in the subject of *incorruptibility*, of which we have no affirmative upon this earth; yet gold comes nearest to an incorruptible body."

The other examples Bacon adduces seem rather to belong to the *Instantiæ Ostensivæ*, unless he means to point them out as showing the limits of nature in some of the *accompanying* instances: "of this kind," he says, "are gold, in weight; the whale in bulk of animal body; the hound in point of scent; the explosion of gunpowder, in sudden expansion."

13. The next instances are called *Instantiæ Fæderis*, or instances of *alliance*, or *union*; in which *natures*, properties, or qualities, supposed to be dissimilar and heterogeneous, are, on investigation, found to approach nearer to each other, if not to be the very same. These, it is observed, are of great use in leading us, from resting in differences, to *genera*, or general classes. Bacon adduces his favourite subject, *heat*. He says that, in his time, the heat of the *sun*, that of *animals*, and that of *fire*, were supposed to be perfectly different in their very *natures*. He rejects this supposition, and illustrates his meaning, with regard to these instances, thus:—"we have an instance of union in the case of *grapes* ripening sooner than the grapes of the same vine out of doors, if one of the branches be trained within side a room where a fire is kept; so that culinary fire will ripen grapes, which is supposed to be peculiar to the sun's heat." He also instances the reasoning faculty in man, and the sagacity of brutes, as in some cases so nearly approaching to the appearances of originating in one common nature, as to merit particular inquiry.

14. More important than the former, are the *Instantiæ Crucis*, *crucial* instances; so called, after Bacon's manner, from the crosses, or way-posts used to point out roads, because they determine at once between two or more possible conclusions.

"These instances," says the author, "are of such a kind, that, when in search of any *nature* (cause), the mind comes to an equilibrium, or is suspended between two or more causes, these facts decide the question, by rejecting all the causes but one." In these cases, each of the sup-

posed causes equally accounts for the appearances, and it is the part of the inquirer to contrive some experiment, or discover some fact, applicable to the given question, which can only be explained by *one* of these causes; by which all uncertainty vanishes, and the true cause becomes known. It is very common to speak, both in science and common arts, of *tests* and *experimenta crucis*. These are sometimes decisive both ways, and sometimes imperfect, or what may be called *unilateral*. Thus, if a flame burns in any gas submitted to experiment, we conclude generally that there is oxygen in the air; but if it does not burn, we cannot, therefore, conclude that there is none, for it may be in too close combination with some other gas to support flame. But a perfect test would be weighing any gas; for if it be heavier than common air, in the ratio of 1.435 to 1.2, it is oxygen; if lighter or heavier it is not. Thus, too, in discussing whether a given writing be innocent or libellous, that is, maliciously composed, or composed with any improper motive of any kind, the truth is a unilateral test; for if the allegations be false, there must be malice; but there may be malice also, though the matter stated be true. There would arise very great distinctness in argumentation, were we to adopt this convenient phrase of a complete and an incomplete or unilateral test—many of the errors in reasoning, especially upon moral subjects, arising from mistaking incomplete for complete tests.

In order to illustrate this division of instances, Bacon institutes an investigation into the causes of the *tides*; but the discussion is not founded on sufficient *data*; is confused by being involved with a question upon the Copernican doctrine of the rotatory motion of the earth; and the whole terminates unsatisfactorily. To determine the true theory of the tides was reserved for Newton himself; but he did it upon the genuine principles of the Baconian philosophy.

The question whether rotation belongs to the earth, or to the heavens, generally, is also introduced; and here Bacon evidently inclines to the old hypothesis, namely, that the heavens revolve round the earth which remains at rest; though he allows that, if any comet should be observed not to obey the apparent law of the celestial motions from east to west, this would be a *crucial* instance, showing that there can exist in nature a motion contrary to the visible, diurnal motion, as it appears to the sense. This question might have been determined by observing what is called, in the language of astronomy, the motion of the planets *in latitude*; that is, their deviations from the plane of the ecliptic, or the sun's apparent annual path among what are now called the fixed stars. These deviations present a set of appearances not to be reconciled with the Ptolemaic system, which makes the earth the centre of the planetary motions, but are easily explained on the theory of Copernicus, or that of the sun being at rest in the centre. This, therefore, would have been an instance of the class before us, against the Ptolemaic hypothesis, and strongly in favour of the Copernican doctrine, though some other appearances of the heavenly bodies might accord equally well with either of the two theories.—In his remarks on the subject of gravity Bacon is more happy. He proposes to solve the question whether or not bodies tend towards the earth in consequence of an attractive power belonging to it, by ascertaining whether they fall with less velocity at greater distances from it;

and this is to be done by observing whether or not the pendulum moves more slowly at great heights above the earth's surface. Both these queries have long been satisfactorily answered.

Chemistry is rich in these *Instantiæ* or *Experimenta Crucis*. The great object in experimental philosophy is, to institute some experiment which shall be similar to another in all respects but one, which, in order to be perfectly satisfactory, the method of induction generally requires. Hence, in those branches of science in which the objects of inquiry are less completely under our command, and less capable of being put to the test of varied experiments, it is difficult to distinguish the causes; and to assign to each its own proper effect. This is often the case in *intellectual* and *moral* inquiries, in *political economy*, and also in *medicine*. Chemistry, which is so completely a science of experiment, furnishes notable instances of the present class.

The celebrated *Lavoisier* performed an experiment of this kind, which exploded the doctrine of *phlogiston*, as held by former chemists. It is well known that when metals are calcined in the fire, the weight of the mass becomes greater after the process than before. The cause of this fact was a subject of inquiry. It was supposed, from some circumstances, unnecessary to be detailed, that in the calcination of a mass of tin, for instance, a certain substance is actually driven off by the fire. To this substance, the name of *phlogiston* was given; and as the metal was heavier after its escape than before, it was supposed itself to possess what they termed absolute levity.

*Lavoisier* instituted the following experiment: a quantity of tin was put into a glass retort, and hermetically sealed; the retort, with its contents, was then carefully weighed. The proper degree of heat was next applied, and the metal was calcined; and now the weight was found to be exactly the same as before the process: nothing therefore could have escaped through the glass. When the retort had cooled, it was opened, and the air rushed in, showing that a partial *vacuum* had been produced. The retort and its contents were now weighed a third time, and it had gained ten grains in weight: ten grains, therefore, of air had rushed into the retort on its being opened. The *calx* was then taken out, and was found to weigh exactly ten grains more than it did before calcination. The ten grains of air, therefore, which had disappeared, and had been replaced by the same weight of air, on the retort being opened, had combined with the metal during the process. This most satisfactory experiment led to the knowledge of oxygen gas, that species of air which combines with metals when they are calcined, and the doctrine of *phlogiston* was exploded.

15. Next in order are *Instantiæ Divortii*, instances of *separation*; "which indicate the separation of those natures which for the most part are found together. These differ from *instantiæ crucis*, as determining nothing, but only admonishing us of the separation of one nature from another." This seems a very general distinction, and not very applicable to practice. It is followed by some curious remarks by way of illustration. *Bacon* says that *agency* in general belongs to some substance; but doubts whether the attraction of a magnet does not furnish an example of this agency, or virtue, being neither in the magnet nor in the body attracted, but between them both. He supposes, therefore, that "natural agency, or power," may subsist for a time

without a substance; and this he would call an *instance of separation*. He makes the same remark with regard to the attraction of the earth.

It is obvious that there is here a confusion in the use of terms; and a want of simplicity in forming the notion of *cause* and *effect*. *Agency* is first spoken of as a quality belonging to some agent; and afterwards as a *real existence*, independent of an agent: this would be to introduce an additional agent; and to suppose, after all, that we know more of cause and effect than we actually know, which is, that one class of events uniformly goes before another class, which may be called their corresponding events; or that a certain *antecedent* always precedes a certain *consequent*. Bacon, however, singularly founds, on these supposed instances of separation, a fanciful argument for *immaterialism*, by way of corollary, which he introduces as of great importance; alleging that "if natural virtues and agencies may subsist without a body for some time in space," this may lead us to a conception of the existence of an incorporeal substance:—its existence, however, rests on better evidence, and strictly inductive, for we know the existence of matter only by its effects on our mind through our senses, and we know the existence of mind by our consciousness, or by the reflexion of the mind itself on its own operations. We have, therefore, the same kind of evidence, in a high degree, for the existence of mind as of body.

## II. *Instances tending to assist the Senses.*

The above general name is given by Lord Bacon to the five orders of instances which follow. They are called, in his usual technical style, *Instantiæ Lampadis*, instances of the *lamp*, because they propose, chiefly, to correct or inform the senses; the accurate impressions and informations of which, it is evident, are of the utmost importance in philosophical inquiries.

16. Of these five, the *first* are the *Instantiæ Januæ*, instances of the *portal*, assisting the immediate *action* of the senses, and more particularly the *sight*. Of this kind are optical instruments in general, and speaking and hearing trumpets. Bacon mentions the *telescope* as the invention of Galileo, and as bringing into view the innumerable stars of the milky way, the satellites of Jupiter, the unequal surface of the moon, and the spots in the sun; but, as he had not the opportunity of verifying these discoveries for himself, the admiration he expresses for them is tempered with some doubt as to their reality. He also notices the *microscope*, and instruments for *measuring* distances, as examples.

17. The *second* of this class are the *Instantiæ Citantes*, *summoning* instances; so called because they cite things, as it were, to the bar of the senses, enabling us to perceive things which were before imperceptible.

Among the causes why things escape the senses, are enumerated, *distance* of place; the *interposition* of some other body; the *unfitness* of the object to impress the senses; the shortness of the *time* during which, in some cases, the object may act on the senses; and the object, as it were, sometimes *overpowering* the senses. Whatever remedies these causes are instances in point. Bacon notices the *pulse*, as bringing to light conditions of the human frame, not cognizable by other means. He also remarks that very swift *motion* requires to be well-measured, in order to compensate for its escaping the senses;

this is now done with regard to *sounds*; and by means of the eclipses of Jupiter's moons, and the aberration of the fixed stars, the velocity of *light* itself is measured.

Other examples may be adduced from modern science: as the *barometer*, and the *air-pump*, which show the weight and elasticity of air; and the experiments in pneumatics, in general, and in electricity and galvanism, have rendered certain the existence of things, which had before entirely escaped the senses, as the *gases*, or elastic fluids. To the same head may also be reduced the late wonderful discovery of a moving magnetic fluid, or an action circular and perpendicular to the electrical current, yet connected with it.

18. *Thirdly*, follow the *Instantiæ Viæ*, instances of the *road*. "These," says Bacon, "we also term *jointed* instances, as indicating the operations of nature gradually continued; and these rather escape the observation than the senses of men." There is a propensity in men, he remarks, to be contented with viewing nature only by "fits and starts," at intervals, and when her processes are finished, while they neglect to watch her gradual method of working. This is the result of indolence. Nature's operations, however, should be carefully observed, while processes are going on, as we stand by and see the operative manufacturer carry on his work. Examples of these instances are the *vegetation* of plants; the *hatching* of eggs, throughout all their stages; such processes as *putrefaction*; and in unorganized bodies, *distillation*. These instances are somewhat similar to the *instantiæ migrantes*.

19. The *fourth* are the *Instantiæ Supplementi*, instances of *substitution*, "or those to which we have recourse," says our author, "by way of refuge, when the proper instances cannot be had." He names the *magnet*, which attracts iron through various substances which may be interposed; and adds, "perhaps some medium may be found to deaden this virtue more than any other medium; such an instance of *substitution* would be in the way of degree, or *approximation*;" that is, it would approach toward destroying the magnetic virtue. Perhaps iron has this quality in a higher degree than any other substance.

20. The *fifth*, and the last enumerated, of this class, are the *Instantiæ Persecantes*, sive *Vellicantes*, *compulsory* instances; which are thus explained. "We call them so because they *twitch* the understanding (vellicant); and because they cut through nature (persecant). They are those facts which rouse the mind to a perception of the admirable and exquisite subtilty of nature; so as that it may be awakened and stimulated to due attention, observation, and research." Bacon means, in short, those facts, which force our attention to things which are apt, from their minuteness and subtilty, to escape our observation. His remarks on these instances show how alive he was to what is curious and admirable in the laws of nature; and exhibit the genuine spirit of a philosophic observer.

Some of his examples are the following: a *drop of ink* in a pen, which is capable of so great a number of divisions into letters; in writing; the amazing length to which a *wire* may be drawn; the exquisite structure of *animalculæ*; the tincture which a little *colour* gives to a quantity of water; the small quantity of *musk* that will perfume a room, without losing any of its weight; the great

volume of smoke which is extricated from some substances, as *incense* ; the *notes in music*, which are so accurately conveyed through air, wood, and other mediums, and reflected so swiftly and yet so distinctly in *echoes* ; *light* and *colour* passing so rapidly through masses of solid or fluid matter, as through glass, or water ; and at the same time conveying to the eye a great and exquisite variety of images, though the light suffers refraction and reflection ; the *loadstone* attracting iron through solid bodies. To these are added the multitude of natural *operations* that are going on in the universe at the same time, without interposing with each other ; as, for instance, *visible objects* are seen through the air ; numerous *percussions* and articulate *sounds* are acting on it ; numerous *odours*, as of flowers, are passing through it ; also *cold*, *heat*, and the *magnetic* attraction : all these actions are continually going on, and innumerable more without obstructing each other.

Our laborious author subjoins, what he calls *limiting* instances to this class. Thus, though one action or operation of nature does not disturb another of a *different* kind, yet this is not exactly the case with regard to actions of the *same* kind. The sound of a flute, and the smell of a rose, may both pass through the air, and make impressions on the senses at the same time ; but the report of a cannon drowns the voice : the light of the glow-worm, if emitted in the sun-beams, is not visible ; and a stronger odour overpowers a weaker.

### III. *Instances leading to Practice.*

THIS division, to which Lord Bacon gives the general name of *Instantiæ Practicæ*, *practical* instances, contains those which are of principal use in practice ; or in the actual effort to raise the improvement of art on the foundation of science, and thus to reduce our knowledge to some valuable purposes.

The instances of principal use in practice he regards as of *two* kinds, applicable to the two ways in which he considers that knowledge may fail of leading to actual results. This failure may be occasioned by our knowledge not being sufficiently *accurate* and precise, though sound as far as it goes ; and this is often the case in natural philosophy, from objects not being exactly measured and estimated. Or the practical result that is desired may fail, through the process or experiment not being sufficiently *simplified*, but, on the contrary, encumbered and confused with operations that do not necessarily belong to it. Hence the "practical instances" are divided into two classes, of which the *first* are the *Instantiæ Mensuræ*, instances of *admeasurement* ; of which he makes four kinds ; and in which some estimate of the qualities and actions of bodies is to be formed, in order to remedy the first of the two above-named sources of failure ; namely, the *want of precision* in our knowledge ; and to aid in converting knowledge into power.

#### (1.) *Instantiæ Mensuræ, Instances of Admeasurement.*

21. The *first* of these are the *Instantiæ Radii*, or instances of the *measuring-rod* ; that is, cases in which things are to be measured in respect of their relation to *space*. "For," says Bacon, "the forces and motions of things operate within certain spaces that are not indefinite and casual, but determinate and finite ; and the due observance

of these spaces in every subject of inquiry is of great importance to practice."

He remarks, for example, that many qualities and properties act only by *contact*. In the *percussion* of bodies, motion is communicated by the impelling body touching the impelled; in the senses of *taste* and *touch* also the effect is produced by contact; so in *external remedies* used in surgery. Some agencies act at *small distances*, as in the case of *amber*, and the *magnet*, which attract certain substances within a certain sphere. Other agencies operate at *great distances*, as *heat*, *odours*, *sounds*, and especially *light*, the effects of all which, on the senses, are perceived when the sources of them are remote from us. The attraction of the *moon* on the sea is added, which Bacon thought a probable cause of the tides, though he does not seem to have considered his inquiry into the subject to have been sufficient to enable him to decide the question. Now all these agencies, it is argued, whether they take place at smaller or larger distances, are bounded and finite; and it is an object of science, to ascertain their *maxima*, or extreme limits; and how far their effects depend on the bulk and quantity of matter in the bodies of which they are the properties; on the peculiar nature of the properties or qualities themselves; or on the fitness or unfitness of the mediums through which the agencies take place. Cases also are noticed in which things act *only* beyond given distances, and never by contact; as in *vision*, where the *focus* must be attended to. These examples relate to *progressive motions*: the *expansion* and *contraction* of bodies were also to be regarded as kinds of motion, the laws and limits of which ought to be subjected to admeasurement.

The *Instantiæ Radii* may, it is evident, be illustrated further, by numerous instruments now used in experiments in natural philosophy; and the greater part of which were unknown to our author. The *thermometer*, indeed, was extant in his time, as a new invention, and furnished him with one source of his experiments on *heat*, as we have seen in the *instantiæ ostensivæ*: this instrument has been the principal means of furnishing us with what we know of the agency of heat, even up to the present time. The *hygrometer* is another instance: this instrument, which has been greatly improved by Professor Leslie, enables us to measure the quantity of moisture contained in the air. To these may be added all our instruments for measuring lines and angles, or *mathematical* and *astronomical* instruments generally: also those instruments which measure weight or force; as the common *scales*, the *hydrostatic* balance, and the *barometer*.

No part of Bacon's work is more calculated than this to show the comprehensive view he took of the agencies of nature, even when physical science was as yet in its first dawn. The instances in which bodies act on each other at a distance led him to form some confused idea of that universal principle, *gravitation*, which Newton afterwards so triumphantly demonstrated and applied. He suggests that there may be some kind of "magnetic virtue which operates by consent, between the globe of the earth and heavy bodies; or between the globe of the moon and the waters of the sea; or between the starry heavens and the planets, by which they may be drawn to their apogees," or greatest distances from the earth.

These *Instantiæ Radii*, which point out cases of quantities to be measured, are introduced by Bacon merely as useful in practice: they might, at the same time, have been considered as highly important, in what he terms the discovery of *forms*, or the inquiry into the natures, essences, or causes of the objects of investigation, so far forth as they may be approached. Newton found that *gravity* not only makes bodies fall to the earth, but also retains the moon in her orbit: now this could never have been shown without the previous determination of several quantities, as the law of *accelerated velocity* in falling bodies; the length of the *earth's radius* or the distance from its centre to its circumference; the *moon's distance* from the earth, and the *velocity* with which she revolves round it in her orbit. A comparison of these elements, viewed in connection with the *laws of motion*, could alone have proved that it is the same kind of force which brings a stone to the ground, and keeps the moon in her proper course. In this case, therefore, as in many others, the instances in which geometrical measures are assigned and compared, the *theory* of physics has been eminently advanced.

22. The *second* class of the instances of *measure* are termed *Instantiæ Curriculi*, instances of the *course*, in which the qualities and actions of bodies are measured by *time*. Hence Bacon also calls them *instantiæ ad aquam*, instances of the *water-glass*; alluding to the *hour-glasses* of the ancients, in which they employed water instead of sand. "For," says he, "every movement or action of nature is performed in some portion of *time*; one indeed more swiftly; another more slowly; but, all in a certain number of moments, adapted to nature. Even those actions which seem to take place in the *twinkling of an eye*, as we say, are yet different in time, as to more or less."

Familiar examples of this class are all the more obvious movements of nature, as seen in the revolutions of planetary bodies; the ebb and flow of the sea; the fall of bodies to the earth; and all animal and mechanical motions. Also the velocity of sound, as witnessed in the firing of guns, and in thunder; and of light, as exemplified by calculation of the times of the eclipses of satellites, and even more remarkably in the aberration as discovered by Bradley. The *expansions* and *compressions* of bodies also, and *explosions*, as in gunpowder, must have, in each case, their own proper *times*, if we could accurately measure them.—In many cases nature is, as it were, prevented from producing her effects, for want of due time for her operations; the hand may be rapidly passed through flame without being burned; small vessels of water may be swung round in such a manner, vertically, as not to be spilled; and a ball fired across the axis of vision is not seen, because the motion is too rapid for the eye to be impressed by it.

One passage, which occurs under this head, is too remarkable to be omitted, as presenting an anticipation of the very examples we have just adduced, though commented on afterwards by the author in a doubtful manner. "Some cases have produced in me a suspicion altogether surprising; namely, whether the face of the serene and starry heavens be seen at the very time it exists, or not till some time later; and whether there be not, with regard to the light of the heavenly bodies, a *true* time and an *apparent* time, as well as a true place and an *apparent* place, according to the astronomer, on account of *parallax*; so

incredible does it seem that the rays of the celestial bodies can instantaneously pass to us, through such an immense space of miles, and not require even some considerable portion of time."

23. *Thirdly*, of the same class are the *Instantiæ Quanti*, instances of *quantity*, (literally, of how much.) These are cases in which the *virtues* or properties and effects of things are measured by the quantity of matter they contain. Examples adduced are that large collections of water do not easily become stagnant, like small ones; wines are matured and improved by being bottled off in small quantities; a magnet attracts more iron than any part of it when separated, though masses of all sizes as well as densities are equally attracted to the earth; sharp and angular points penetrate and divide bodies the most easily. The effects of *quantity*, therefore, Bacon observes, are to be carefully estimated. The importance of this to practice is obvious, if we name only chemistry and medicine.

28. The last of the four instances of measure are the *Instantiæ Luctæ*; instances of *resistance*; "which," says the author, "we also call *prevailing* instances; that is, such as show the subjection of *virtues* to one another; or which of them is the stronger and prevails, and which the weaker and submits; for the motions and struggles of bodies are no less compounded, recompounded, and complicate than bodies themselves."

In order to illustrate these *instantiæ luctæ*, Bacon introduces no less than *nineteen* kinds of *motion* (*motus*) or resistances, all differing, as he considers, from each other, and in their effects. He here, however, employs the word *motus* in a more general and less proper sense, than merely as signifying actual *change* of place; for in some of the cases nothing more is meant by it than certain *tendencies* in matter to resist certain external forces; thus his *Motus antitypiæ* he defines to be the resistance or repugnance which all bodies discover to the annihilation of their minute parts—it is, in short, the *indestructibility of matter*; a property which, so far as we are acquainted with nature, seems to be universal. Science may resolve matter into its component parts, or go far at least towards doing so; its form may be from the solid to the fluid, or the *aëriiform* state; and it may combine into various ways with other matter; as may be seen in almost every chemical process; and in the dissolution of animal bodies after death: but only the Power that created matter can reduce it to nothing. To a careless observer, the fallen leaves of vegetables, which rot upon the ground, would appear to be lost for ever; but *Berthollet* has shown, by experiment, that whenever the soil becomes charged with such matter, the oxygen of the atmosphere combines with it, and converts it into carbonic acid gas. The consequence is, that this same carbon is absorbed by other vegetables, which it clothes with new foliage; these, in their turn, decay, and thus resolution and renovation go on to the end of time. In short, in the whole circle of the material world, we never witness a single instance of destruction or annihilation.

Bacon even enumerates, among these kinds of motion (*motus*), what is now called the *inertia* or *inactivity* of matter; a property by which it resists any change endeavoured to be made in its state, either of rest or motion; and which property is the foundation of the three *laws of motion*, as delivered by Newton in his *Principia*. Bacon singularly

calls it *Motus decubitûs*, aut *motus exhorrentiæ motûs*, the *motion* (tendency) of *repose*, or of *avoiding motion*. Among the kinds of motion, or tendency, mentioned as belonging to the *Instantiæ Luctæ*, are also the following :—

*Motus libertatis*, the motion of *liberty*; or, as our author means, *elasticity*; that property of bodies by which they restore themselves to their original figure, after compression; as is seen in the springs of watches; air in air-guns; Indian-rubber, etc.

*Motus hyles*, from a Greek word signifying matter, is the capacity of *expansion*; or the tendency of matter, under certain circumstances, to enlarge its bulk: the effect of *heat*, in expanding bodies; and gun-powder in explosions, are named as familiar examples.

*Motus continuationis*, or the attraction of *cohesion*, by which the particles of the same mass are kept together, as forming its component parts. The modern experiments on the strength of different substances, by finding what weights are necessary in order to tear them asunder, are founded on this property. These experiments have been made with bars of wood, metals, glass, etc., of given dimensions, and it has been found that the cohesive strength of a body is in the joint proportion of its elasticity, and toughness, and the area of its section. Newton conjectured *cohesion* in bodies to be that which constitutes them of different forms and properties.

*Motus indigentiaæ*, the motion of *preference*; or the tendency which bodies have to unite with some bodies rather than with others. Thus the surface of mercury in a glass bottle appears *convex*, but in a metallic vessel, it appears *concave*, in consequence of its tendency to adhere to the sides of the vessel, as it has a greater attraction for metal than for glass. Chemical attraction, or affinity, also furnishes innumerable examples. Bacon seems to confound this *elective* attraction with *capillary* attraction; from which it differs as much as it does from the attraction of cohesion, or aggregate affinity.

*Motus congregationis majoris*, the motion of *greater aggregation*, or, if we may distinguish it from cohesion, in modern language, the *attraction* of *aggregation*, “is that,” says Bacon, “by which bodies are carried to the masses of their own natures.” This may be illustrated, if we carefully observe two small globules of mercury moved towards each other along a smooth surface: their mutual attraction will be evident immediately before they unite into one globule; or, if two pieces of cork be floated in a basin of water, not nearer to its edge than to each other, they will visibly approach, and at last come into contact.

*Motus fugæ*, or the *motion of avoidance*, though very crudely and almost ludicrously illustrated by Bacon, has its foundation in fact, and is that property of matter which is now called *repulsion*. Newton found that a convex *lens*, when put upon a flat glass, remained at the distance of the  $\frac{1}{137}$ th part of an inch; and that a very considerable force was requisite to diminish this distance. Again, though steel is so much heavier than its bulk of water, yet if a dry *needle* be placed carefully upon the surface of a basin of water, it will float; the repulsion of the water preventing its sinking. Also the particles of all *gases* seem to repel each other, as appears from their elasticity. According to Boscovich, the atoms of which bodies are composed are capable of acting on each other with a force, which differs in intensity, and in kind, according to

the distance. At sensible distances the force is *attractive*, and diminishes inversely as the squares of the distance. At the smallest distances the force is *repulsive*; it increases as the distance diminishes; and at last becomes infinite or insuperable. Hence if Boscovich's theory be correct, absolute contact, however paradoxical this may appear, is impossible. Facts, at all events, prove, in many cases, a repulsive power, whatever be its precise laws; and to these facts may be added, though somewhat differing from the former examples, the repulsion of electrified pith balls; also of the similar poles of two magnets. In the latter case, all the force of a strong man has proved insufficient to make the two north poles touch each other.

*Motus assimilationis* is the tendency of certain bodies "to convert other bodies related to them," says Bacon, "into their own substance and nature." He instances *flame*, which multiplies itself by decomposing certain substances; also animals, which seem to have a power of assimilating their food into the nature of their own bodies. However vague the notion of *assimilation* may be, Bacon's distinction here is sufficiently obvious.

To the above is subjoined *Motus excitationis*, or a tendency to *excite* and diffuse a quality. Thus *heat* diffuses itself when other bodies are heated; and the magnet gives to iron a new property without losing its own power. The distinction of this from the former *motion*, or property, lies in the circumstance of there being here no *transformation* of substances, but only a diffusion or multiplication of some virtue, or quality.

*Motus impressionis*, or the *motion of impression*, occurs where there seems to be a continual communication of impulses from the body which is the original source of it: the rays of light are an example, because darkness is the effect of the removal of a body from which they flow; also sounds, which cease if the vibrations of the sonorous body are suddenly stopped.

*Motus pertransitionis*, or *motion of passage*, has respect to the effect which the *medium* through which agencies are carried on, may have on promoting or hindering their power: thus *heat* is differently *conducted* by different bodies, or passes through them with various degrees of velocity; metals conduct it rapidly; earthy substances less so; and wood still more slowly. A ray of light, in passing from a rarer into a denser medium, as from air into water, becomes *refracted*, or is turned out of its course, and is bent towards the perpendicular. In an exhausted receiver, a bell can scarcely be heard to sound through the *attenuation* of the medium: and the experiments of Hauksbee and of Dr. Priestley show that, when the air is condensed, the sound is louder in proportion to the *condensation*; that is, in proportion to the quantity of air crowded in, and which operates as the medium of the sound, or the substance on which the vibration is first made, to be communicated through the atmosphere to our ear.

*Motus rotationis spontaneus*, the motion of *spontaneous rotation*, as seen in nature, is also mentioned; to which, says Bacon, belong the following considerations: the centre; the poles, or axis; the circumference; the velocity; the order, as from east to west, or west to east; the excentricity, if any, or deviation from circular motion; the declination, or the approach to, or recession from the poles; and

the variation of the poles themselves, if moveable, or, in modern language, *libration*.

The other species of *motus* introduced by Bacon, under the *Instantiæ Luctæ*, are somewhat more obscure and ill-defined. *Motus nexus*, or the motion of *connection*, seems to apply to those cases in which a *vacuum* is produced, and a fluid rises in consequence of the outward pressure being taken off, as in the common pumps and the barometer. *Motus minoris congregationis*, or the motion of *lesser aggregation*, is illustrated by the *cream* of milk floating on the surface, which Bacon attributes more to the attraction which homogeneous particles have for each other, than to the specific gravity of the cream being less than that of the milk.—*Motus magneticus*, or *magnetical* motion, is applied to the attraction of the heavenly bodies, from an idea, probably, that it might be a species of magnetism.—*Motus configurationis*, aut *situs*, motion of *configuration*, or *situation*, may apply to the shooting of *crystals* into their own peculiar forms; or to the fixed tendencies of bodies to preserve the disposition of their internal parts, as their threads and fibres, and their cellular or solid structures. Bacon singularly refers hither the inquiry into the direction of the celestial motions; also the polarity of the magnetic needle.—*Motus politicus*, or the motion of *government*, is excessively fanciful and obscure: it is said to be the ruling power, or property in any body, controlling all the rest, and it “*principally reigns in the spirits of animals*.” We should scarcely suspect Bacon of *materialism*, yet he seems to have been extremely disposed to introduce mechanical causes in order to account for effects which they are entirely insufficient to explain. *Motus trepidationis*, or the motion of *trepidation*, he illustrates by the hearts and pulses of animated beings.—This long dissertation on *motions*, whatever crudities and fancies it may contain, is very curious and interesting, and we have thought it worth while to analyse it briefly, as showing on what properties in nature our discriminating author founded his distinction of *Instantiæ Luctæ*.—This class of facts might be further illustrated, were it necessary, by the instruments used in England, by Cavendish, and in France by Coulomb, for experiments on *torsion*; a term employed by the latter philosopher to denote the effort made by a thread which has been twisted to untwist itself. These instruments, by means of the force of torsion, measure very small, and almost insensible actions.

The three remaining practical instances are termed *Instantiæ Propitiæ*, or instances *propitious* to practice, in the way of immediately directing, simplifying, and facilitating it.

## (2.) *Instantiæ Propitiæ, Instances facilitating Practice.*

25. Of these, the *first* are the *Instantiæ innuentes*, *intimating* or *directing* instances; that is, those which tend to free practice from useless pursuits, and direct it chiefly to such as are beneficial and advantageous to mankind; such facts in nature and in experimental science as are worthy of being attended to and pursued, because they open direct prospects of usefulness and improvement, as it respects the arts and conveniences of life.

26. The *second* of this order, Bacon terms *Instantiæ Polychrestæ*; or things that are *generally useful*, as applicable to a great variety of

investigations, by shortening and facilitating the process. To this head belong the method of conducting experiments, and the instruments and apparatus to be employed in them, which he proposed to treat particularly in a subsequent part of his work. He here notices a few general considerations which are essential to practice in a great variety of cases.

In experiments, such things are carefully to be excluded as might *disturb*, or *modify* the given process; as the common *air*, where this can be supposed to have that effect; for the same end, the matter, strength and thickness of the *vessels* in which certain processes are carried on is to be attended to; also the manner of *closing* them where they are to be closed, as by luting, or hermetically sealing, for instance; the rays of the *sun* too must often be excluded. The effects of *compression*, *condensation*, *agitation*, *extension*, *rarefaction*, etc., are to be observed in many chemical and other processes. And here Bacon's conjecture must not be omitted, that it was possible "air might be converted into water by condensation." *M. Biot*, if we mistake not, first proved this conception of our great philosopher to be true, and succeeded in forming water from hydrogen and oxygen, by *compression* only, independently of the electric spark. To these considerations are to be added that of the agency of *heat* and *cold*; and the modification these may introduce into certain experiments; also the effect produced by the *medium* through which the heat may be communicated to any substances, by the structure of *furnaces*, and by the manner in which the fire may be *applied*. Again, regard is to be had to the effect which may be produced by a process being left to go on undisturbed, and by itself, for a longer or shorter *time*. The figure, position, and situation of the vessels that are employed, are to be considered. The *sympathies* and *antipathies* of bodies, as Bacon terms them, are to be noticed where these may have an influence; of these, chemical *affinities* and *elective* attractions are obvious instances. Lastly, advantage is to be taken of what is known with respect to all the above particulars, in order, by their means, to modify, combine, and vary experiments.

27. The *third* of the instances "*propitious*" to practice, and the last of the "*prerogative*" instances, are named *Instantiæ Magicæ*, *magical* instances; and Bacon understands by this term those facts in which great and wonderful effects are produced by apparently trifling causes. Nature, he observes, "is herself sparing in these instances;" but in harmony with the very sanguine, and we fear illusory expectations which we have seen he entertained, he adds, "what she may do, when further searched and entered into, and after the *discovery of forms*, *latent processes*, and *concealed structures*, will appear to posterity." He notices as *magical* or marvellous instances, the power of *fire* to multiply itself; the effect of *poisons* on the human frame; the communication and apparent *multiplication of motion* in a set of wheels, each impelling the other; the *loadstone* animating a number of needles without loss of its own magnetic power; the origination of *motion* in explosions of gunpowder, and also of gas in mines.

Tinctured somewhat, perhaps, with the wild notions of *alchemy* then prevailing, Bacon seems to augur from such facts as the above, that wonderful things may be accomplished by human power, in

“changing bodies in their smallest parts, and in all kinds of transformations.” He adds, however, “of these we have hitherto no certain indications. And as in things solid, true, and useful, we aspire to the highest perfection; so we perpetually despise, and to the utmost of our power discard and reject such as are vain and empty.”—Here ends the doctrine of “*Instances*” and all that was finished of the *Novum Organon* by its illustrious author.

It was Lord Bacon’s design, after treating of the *instances*, of which we have now given the analysis, to proceed to the *helps* of induction; the *rectification* of induction; the method of *varying* inquiries; the *prerogative natures* for inquiry; the *limits* of inquiry, in a list of *all the natures* in the universe; the reduction of inquiries to *practice*, or to the use of mankind; the *preliminaries* to inquiry; and the *scale of axioms*, or principles.

These eight last topics were deferred, probably, till the author had found time to accumulate more materials, and they were never discussed; so that his work was left in an unfinished state. Several of the particulars, however, here enumerated are not very distinct from some of the heads already treated of, and seem to lead us back over the same ground; whence we may conclude that Bacon was fully aware that, in the existing state of the knowledge of nature and fact, in his time, his system of philosophizing could only be regarded as a sort of outline, or sketch of scientific inquiry, and needed to be worked over and over again, by way of continual approximation to truth.

What more he had to deliver on these particulars we shall not now conjecture; but it may be remarked, that by *prerogative natures* for inquiry, he seems to have intended those causes in nature, or those agencies, which present themselves as of the most obvious and prime importance, in consequence of their involving, frequently, other inquiries: thus *temperature* is so important a consideration in various experiments, especially in chemistry, that *heat* may be considered as an example belonging to the class of what are here technically termed prerogative natures. The project of making an *inventory* (*synopsis*) of *all the natures* in the universe, appears to have arisen out of our author’s very sanguine ideas, as before noticed, relative to the *discovery of forms*. If by *natures* he here means *simple substances*, or those which are incapable of being decomposed by art, it is obvious that such substances may decrease in number with the progress of science. Previously to Sir Humphry Davy’s distinguished researches in chemistry, the simple bodies were supposed to be about fifty in number; the facts he has brought to light, however, make it difficult to say what substances, regarded as simple, may not be capable of analysis: witness this philosopher’s discovery of the metallic bases of the fixed alkalis; his decomposition of most of the earths; and his experiments on sulphur and phosphorus: all these substances were previously thought to be strictly simple.

Though no direct attempt, so far as we are aware, has been made to supply the parts of the *Novum Organon* that are wanting; nor any complete logical system founded on the same basis of induction has been published, which might serve as a perfect directory in philosophical investigations; yet there have not been wanting some efforts of a similar kind, towards promoting the advancement of the sciences.

Descartes wrote a treatise expressly *De Methodo*, or the Method of Science, with the view of remedying the defects of the ancient plan of philosophizing, of which he seems to have been convinced. But though he flourished nearly half a century later than Bacon, and was acquainted with his writings, he pursued a course quite the contrary to that pointed out in the *Novum Organon*; which is the more singular, because, in one of his letters, he seems to acknowledge that if the experimental method of philosophizing were the true one, nothing could be superior to Bacon's rules. Descartes was anxious for a reform in the sciences; and, skilled as he was in mathematics, he was able by his genius to extend the limits of geometry as far beyond the place where he found them as Newton did after him; for he it was, principally, who developed the application of algebra to geometry, on which all modern mathematics rest; yet he was so misled by the humour of framing hypotheses, that his philosophical system is little more than an ingenious romance, and has long ceased even to be read as a matter of curiosity. In physical science, he seems never to have proposed to himself any thing like Bacon's plan of a strict *induction*; for though he did not reject experiment altogether from his philosophy, he employed it in the most loose and inefficient manner possible. He tells us that he was always able to discover *effects* by reasoning: "we employ experiment," he says, "not as a reason by which any thing is proved, for we wish to deduce effects from their causes, and not inversely, causes from their effects. We appeal to experience only, that out of innumerable effects which may be produced from the same cause, we may direct our attention to one rather than another." How different this from the tone of the very first sentence of the *Novum Organon*—MAN, THE SERVANT AND INTERPRETER OF NATURE, UNDERSTANDS AND REDUCES TO PRACTICE JUST SO MUCH AS HE HAS ACTUALLY EXPERIENCED OF NATURE'S LAWS; MORE HE CAN NEITHER KNOW NOR ACHIEVE.

It is evident that such a mode of philosophizing as this was precisely the reverse of Bacon's. Instead of proceeding upwards from effects to causes, or, as Bacon would term it, *raising axioms* from particular instances, Descartes proceeded directly in the contrary order, from causes to effects, or from generals to particulars; and this without having previously established his general conclusions in a scientific manner, or received sufficient evidence that they could be properly applied to the given particular cases. In this way he proposed to explain all the phenomena of the universe *à priori*, that is, by deducing them from his general principles by abstract reasoning; and instead of the patient caution which generally distinguished Bacon's vast analogical powers, Descartes, while he sets out with a scepticism so universal as even to make him not admit his own existence till he has attempted to prove it, at the same time exhibits, in his theories, the most unphilosophical credulity and rashness. Hence, though he certainly has the merit of great original genius in pure mathematics, his physical speculations produced the hypothesis of a *plenum* and *vortices*; or that the planetary bodies are whirled round by a subtle matter of which the universe is full; an hypothesis which, it scarcely needs be remarked, was equally applicable to all the systems of astronomy, whether that of Ptolemy, Tycho, or Copernicus; and rested upon the assumption of motions not proved to exist; or even if they did exist, just as

much needing inquiry and explanation as those they are called on to solve.

M. *Tschirnhausen*, a member of the Royal Academy of Sciences, at Paris, published, in 1687, an essay, entitled *Medicina Mentis, sive Tentamen genuinæ Logicæ*, "Assistance to the Understanding, or an Attempt towards a genuine Logic; in which is discussed the Art of finding general Principles, and the method of discovering unknown Truths." This work, which discovers much ingenuity, is not, however, adapted to practice; and may be regarded as illustrating Lord Bacon's caution in the first book of the *Novum Organon*, with respect to the influence which particular studies may have in biassing the mind in its inquiries after truth. M. *Tschirnhausen*, reflecting on the little controversy there is among mathematicians, compared with the disputes among students in other branches of science, considered that a method strictly mathematical might be applied with effect to these other branches. Hence he thought that unknown truths might be discovered precisely in the same manner in every science, as in pure mathematics. He even fancies that the difference between the "perceptions of the imagination," as he terms the notions we form of things by sensation merely, and the "conceptions of the understanding," such as that a whole is greater than a part, may come under mathematical calculation! In short, by natural philosophy, *Tschirnhausen* seems to understand something not very different from *Descartes*' notion of it above mentioned, namely, a knowledge of the universe demonstrated *à priori* in mathematical order, and confirmed *à posteriori* by experiments.

At an earlier period, the *Hon. Robert Boyle* ably seconded and practically improved the plan of experimental philosophy. This distinguished man, who was born the year Bacon died, was among the first originators of the Royal Society; which was formed, in 1645, for the purpose of improving experimental knowledge on the plan laid down by Bacon. Boyle's valuable experiments in various branches of science show that he had deeply imbibed the spirit of his great master's system; and, independently of his discoveries and improvements, they constitute a most important addition to what Bacon had so loudly called on philosophers to labour at obtaining; namely, a more extensive and accurate history of nature. Many of Boyle's essays contain remarks on the method of pursuing the inquiries of science, highly calculated to facilitate and promote the grand object which Bacon pointed out, and to familiarize to philosophers the practice of an enlightened induction.

*Dr. Hooke*, contemporary of Boyle, a man of great mechanical science, who laid claim to several useful inventions and discoveries, and whose fame is much less than his deserts, partly because he was eclipsed by Newton, and partly because he wearied men with his inordinate pretensions, seems to have formally designed an attempt of a similar kind with Bacon's. He entitles his work "The true Method of building a solid Philosophy; or a *Philosophical Algebra*." "This," he says, consists of two parts: first, the manner of preparing the mind, and furnishing it with fit materials to work on; secondly, the rules and methods of proceeding, or operating with this so collected and qualified *supellex*." All that *Dr. Hooke* has left us of this posthumous piece, is little more than what Bacon has sketched in the first book of the

*Novum Organon.* The second part seems never to have been written, so that what the "Philosophical Algebra" was precisely to have been, must be left to conjecture.

We may safely assert, that whatever more may hereafter be done in the way of rules for scientific inquiries, can only proceed on the plan of Bacon, as the groundwork: for the method of induction is founded on the principles of human nature itself; and only needed to be fairly presented to the minds of men, generally, in order to command their approbation and support. Not, indeed, that the inductive method, as we may here take the opportunity of observing, is properly to be considered as *opposed* to the syllogistic, in which light it has been the fashion to represent it. Induction is not a distinct kind of argument from the syllogism adopted by Aristotle; that is, if by induction we understand as we ought to do, and as Bacon understands it, not merely the process of investigation, and of collecting facts, but also the deduction of inferences from these facts. This deduction is, of course, an argumentative process, capable, if necessary, which is, perhaps, scarcely ever strictly the case, of being put into a syllogistic form; for a syllogism is nothing more than any argument whatever, stated in order, technically, and at full length; it is an expansion of the assertions that are implied and contained in the propositions with which we commenced; and it points out the complete force of what has already been virtually admitted. The fault of the Schoolmen lay in reasoning from *false premises*, that is, in drawing conclusions from insufficient *data*; and in employing the syllogism for the purpose of making discoveries in natural science, without instituting sound philosophical inquiries.

If the real merit of a system is to be estimated by its actual effects, Bacon's *Organon*, and some of his other philosophical writings, must be reckoned among the fairest fruits which the genius of man has bequeathed to his fellows. Let the whole spirit and manner of the writings of such men as *Boyle*, *Hooke*, and *Locke*, who were Bacon's almost immediate successors, be compared with the method of those who preceded him, and it will be impossible not to perceive the commanding influence of Bacon's labours, and the very distinct character they impressed on the next age. Even Newton's incomparable genius might never have awoken to all its strength, unless Bacon had previously cleared the theatre where it was to act, and made a way for the free exercise of its energies, by removing the chief obstructions to its mighty career. The indications and the germ of several of Newton's discoveries are certainly to be detected in Bacon's works; and had Newton been born a century earlier, instead of beginning where Bacon left off, and standing on the vantage-ground reared by his labours, the world might have lost many of the most important advantages he has been able to confer on it, by means of the experimental method. Bacon scattered away the darkness of error from that horizon in which Newton was afterwards to appear, or Newton might never have had power to soar as he did into the third heavens of truth, and to pour such a flood of light over the whole field of natural science, as to excite the admiration and astonishment of his own and all succeeding ages.

Though the triumph of truth over error seems always destined to be a gradual process, it is a well-known fact that Lord Bacon's philosophical writings did not fail to make a very early impression

on the learned world, both at home and abroad. The University of Oxford presented an address to him in 1623, in which he is represented "as a mighty *Hercules*, who had by his own hand greatly advanced those pillars in the learned world, which by the rest of the world were supposed immoveable." This tribute to Bacon's merit as a philosopher has the greater weight, because it was offered, as *Macvey Napier* remarks, "when all motives to interested adulation had been done away by his lamentable fall."

The Baconian philosophy seems, afterwards, to have made greater progress at Cambridge than at Oxford, notwithstanding the above testimony from the latter University to the genius of its author. "*Glanvil* lamented," says *Anthony Wood*, "that his friends did not send him to Cambridge; because he used to say, that the new philosophy, and the art of philosophizing, were more cultivated there than here at Oxford." This was about the year 1652;—Lord Bacon died in 1626. That the spirit of free inquiry in which the *Royal Society* originated, was chiefly owing to the effect of Bacon's writings cannot be disputed. For information on this subject it is sufficient to consult *Bishop Sprat's History of the Royal Society*, and *Dr. John Wallis's* account of his own life. A host of other authorities might be accumulated, were it necessary, in proof of the direct and early influence of Bacon's writings in forming the new English school; of these testimonies a great variety are collected in *Napier's* masterly tract, entitled, "Remarks Illustrative of the Scope and Influence of the Philosophical Writings of Lord Bacon."

On the continent of Europe, his philosophical reputation was early acknowledged. *Dr. Rawley* says that "his fame was greater, and sounded louder in foreign parts than at home;" and that "divers of his works had been translated, more than once, into other tongues, both learned and modern, by foreign pens." In 1652, *Lewis Elzevir* was about to publish Lord Bacon's works in Holland, as writings "long received with the most attested applause of the learned world." *Gassendi*, a strenuous opponent of the philosophy of Aristotle, and of that of Descartes, was one of Bacon's earliest disciples in France, being born in 1592. Bacon's correspondence with *Baranzan* proves how early his writings had attracted notice in Italy. We might add the testimony of *Commenius*, in Germany, so early as 1643, together with those of a number of other philosophers quoted at length by Mr. Napier, all showing that the revival of science, not only in England, but on the continent, is mainly to be traced to the effect of Bacon's writings, and this at no distant period from their publication.

That the labours of our illustrious philosopher should have excited jealousy and alarm in some quarters, and especially among those who were still devoted to Aristotle, is what we were quite prepared to expect. Error and party interest shun the light, and are ever ready to brand all attempts at improvement with the name of dangerous innovation. Perhaps no great endeavour for the welfare of mankind ever escaped this doom, or failed to rouse the tocsin of alarm. A hue and cry was accordingly soon raised against the New Philosophy, and a keen pursuit kept up, with the laudable view, if possible, of putting it down. The *Novum Organon* is now considered harmless enough surely; and in modern times, it has been permitted to slumber be-

tween its covers pretty much unmolested by the majority of mankind, who little know how greatly they are indebted to it for the effect it has had towards producing many of the arts and conveniences of life; but time was, when it was necessary to allay men's fears and jealousies of its doctrines having a sort of magic power to produce "dangerous revolutions," "subvert" governments, and overturn the authority of religion. Such, at an early period, were the alarms of not a few, and among the rest, of *Dr. Henry Stubbe*, who denounced the whole tribe of Experimentalists, with the singularly happy and courteous epithet of a "*Bacon-faced generation*;" and after informing us, in great simplicity, that he has "small regard for deep and subtle inquiries into natural philosophy," says, that "we must rise as high in our resentments" against the said generation, "as the concerns of the present age and of posterity can animate us."

So malignant an aspect, in short, did some imagine Bacon's writings to have on what are infinitely the most important interests of the human race, that *he* was shrewdly suspected of favouring *atheism*, who had eloquently published to the world, "I would rather believe all the fables in the Legend, and the Talmud, and the Alcoran, than that this universal frame is without a mind." We should have supposed that any kind of tendency to irreligion would have been the very last thing that could be imputed to Bacon's works;—but such is prejudice. It is, in fact, a happy circumstance for mankind, that geniuses the most transcendent and original that ever lighted upon our world, who have thirsted the most ardently for knowledge, and have vindicated most boldly the freedom of the human mind from every yoke but that of truth, have been the farthest from meriting such a charge, in the writings they have left us. Such were Newton, and Bacon, and Milton, and Locke.

Though we have given the *analysis* of Bacon's great work, not merely as deeming it a *curiosity* in the history of science, but as tending to recal our attention towards principles to which we owe so much, and the study of which we should be sorry ever to see neglected as superfluous; yet we are free to acknowledge that the whole process, according to the detail which our great philosopher recommends, was strictly necessary in practice, chiefly in the infancy of science; or, where the subject of inquiry is altogether new, and one of which we have little or no knowledge. The world, as to its improvement in science, may, in some degree, be compared to an individual. The proficient in the art of music has no need to recollect at every step the names of the notes in the *gamut*, or the rules he has been taught for fingering the keys; nor would this be possible: when he has once acquired dexterity in music as an art, theory is converted into a true, though mechanical kind of practice: so now that science has made certain advances, and has established a series of truths, it may often be quite unnecessary to go through the whole process of *induction* from the beginning. After certain general and leading principles have been completely authenticated, these may serve greatly to shorten future inquiries, and much time and labour may of course be saved. Thus, after the laws of the reflexion, and the different refrangibility of light, and the nature of the colours which refraction produces, had been satisfactorily ascertained by experiment, Newton had the ma-

terials prepared for explaining the rainbow, nor was it necessary again to institute an inquiry respecting the above laws, as if they were unknown. Newton's *Optics*, it may here be remarked, may justly be regarded as a most perfect specimen of the *Baconian Induction*. Dr. Black's *Treatise on Magnesia Alba and Quicklime*, is also an excellent model of the inductive method, affording similar examples of safely proceeding to further conclusions by assuming things well known.

It must be allowed, also, that, in addition to the effect produced by the collection of facts, and composing a history of nature, and by long practice in the experimental method, inductive investigation has been more modified in some inquiries, by the employment of *mathematical reasoning*, than Bacon, who had not pursued mathematical studies, was prepared to expect. Though he pointed out the use of mathematics, in measuring and comparing the objects of natural philosophy, he was not, nor could he be, aware to what extent geometry and analysis would be applied, in generalising inquiries, and in rendering experiment in some cases less necessary. The laws of motion, for instance, are founded, of course, on experience; but from these laws, once established, the rest of the science of mechanics is chiefly deduced by reasoning. So also in optics, when a ray of light is refracted, or bent from a straight line, as when it passes from air into water, the angle which the refracted ray makes with the surface depends on that which the incident ray makes with it; and we must ascertain by experiment what angle of refraction corresponds to any given angle of incidence; but we must have recourse to geometry if we would know the constant relation which subsists between these angles, and be able to express this relation in general terms applicable to all cases, for, with regard to this, experiment does not directly inform us. But the great triumph of mathematics, as applied to physics, and which Bacon never could have believed possible, has been the discovery of certain phenomena in the planetary motions, never suspected until the sublime discovery of modern analysis indicated those appearances as cases of the general rule.

Perhaps Bacon, moreover, in his zeal against the visionary philosophy of the ancients, scarcely allowed, in his inductive theory, the use which, in some cases, even *hypothesis* may be of in assisting our inquiries. Newton employs almost in the manner of a motto, the expression '*hypotheses non fingo*,' *I do not devise hypotheses*. He might here allude to such hypotheses as the *vortices* of Des Cartes; for he himself, in some cases, used hypothesis. In a subordinate sense of the term, and, indeed, to a limited extent, it frequently appears necessary to do so. Newton's theory of gravitation took its rise from a conjecture suggested by *analogy*; and was afterwards verified by comparing the moon's revolution in her orbit, with the law of accelerated velocity, as exhibited in falling bodies near the earth's surface. Copernicus, in the same manner, was led by *analogy* to the true system of the universe, and the only evidence he could offer in its favour was its *simplicity*. This hypothesis of Copernicus, in the hands of Newton became an established fact. Indeed, in many cases of physical investigation, there is nothing before the mind for it to act on, but two or three different hypotheses, which it is the business of a strict induction to judge of, and to adopt that which most accords with the facts.

Hypotheses become dangerous only when they are admitted as *theories*, and when, instead of being employed as a temporary guide, stimulating the mind of the inquirer to observation and experiment, they are set up as substitutes for facts, and become idols of the imagination, before which reason is to bow. It was in this view that Bacon so loudly condemned them, while it must be acknowledged that he scarcely provided for a cautious and enlightened use of them. "Any hypothesis," as Dr. Hartley well observes, "which possesses a sufficient degree of plausibility to account for a number of facts, helps us to digest these facts, to bring new ones to light, and to make *experimenta crucis* for the benefit of future inquirers."

Whatever defects or redundancies, however, the triumph of the Baconian method for two centuries has enabled us to perceive in the writings of its distinguished author, we cannot look on what he has actually done for science but with surprise and admiration. No one before him seems thoroughly to have been possessed with the idea of the folly of supposing a being of such imperfect and limited faculties as man capable of explaining nature's laws and operations by means of reasonings *à priori*. If there are beings to whom this is given, it is certainly denied to man; and the grand lesson which Bacon taught the world was, that all false philosophy might be traced to a mistake as to the real powers of the human mind, and the proper direction in which, from its nature and present condition, it must always submit to act, in the acquisition of knowledge. It had in general sought to attain to truth by eccentric movements and forced marches, while the only method suited to its capacities was looked on with contempt or disregard—that of simply feeling its way out of darkness into light. That Bacon probably overrated the effects of the inductive method, we have already remarked; this, however, was a very different thing from the ancient error of supposing the mind capable of inventing true theories without the labour of experience. It is certain that Bacon believed it within the limit of possibility to transmute other substances into gold; and on this account he has been identified with the disciples of *Raymond Lully* and *Jordano Bruno*. No one, however, could be more sensible than himself of the general folly of the pursuits of the alchemists; and his belief in *transmutation* arose out of his sanguine ideas of the resources of the inductive method—resources as yet untried and unknown; for we may venture to say that, in his time, there was not a sufficient collection of facts and experiments to authorise the conclusion that even the *essences* of different substances might not hereafter be discovered, when the new philosophy, then only in its infancy, should be matured. Time indeed has not fulfilled these anticipations, but Bacon's speculation with regard to transmutation was entertained after him by Boyle and others; and there is evidence that it was not decidedly opposed even by Newton himself.

The study of Bacon's philosophical works in general, and especially of the *Novum Organon*, cannot fail to be highly beneficial to all persons who are entering on scientific pursuits, and to all who are engaged in inquiries after truth of whatever kind. Their general tendency will be, if we do not greatly err, to inspire a habit of close and patient thinking,—an intellectual independence, which resists all that is merely of the nature of hypothesis, while it bows with implicit

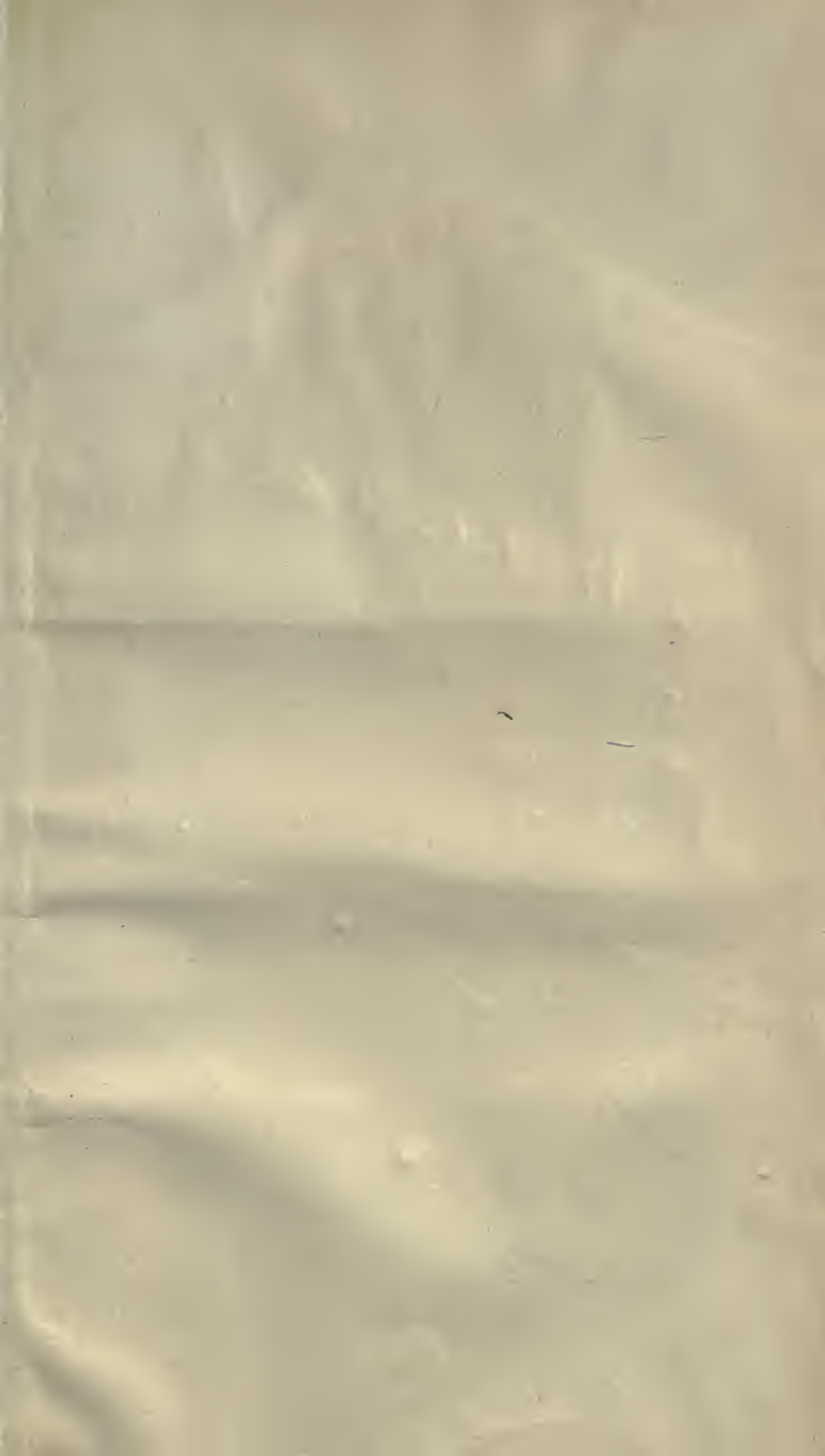
deference to the authority of fact and experience. The nature of the different kinds of evidence; the different subjects to which they are properly applicable; the degree of that sort of evidence that is called moral, which it is reasonable to expect in any given case; the proper limits both of doubt and of belief; the whole order of circumstances of whatever kind that may have any bearing on the impression which evidence may make, or may fail to make, on the mind;—these very interesting topics of inquiry, as well as every other subject relating to moral and intellectual philosophy, are not less properly and strictly within the sphere of the operation of the Baconian method, than the more tangible properties of matter itself, and the laws of the material universe in general. The spirit of the inductive philosophy is in perfect unison with man's intellectual nature; it offers a true corroborative to his faculties in his pursuit of truth; and the more completely this spirit is imbibed, the more shall we be guarded from the extremes of credulity on the one hand, and incredulity on the other.

Bacon's style has been condemned as "stiff and rigid;" and his wit as "often unnatural and far-fetched." He certainly employs, to a considerable degree, the quaint and highly figurative diction which was the fashion of his time. Of this we have remarkable specimens in many of his divisions in treating the doctrine of "*Instances*;" notwithstanding this, however, his style is not so often chargeable with vagueness or obscurity as might be supposed. When it is, this arises usually from his not defining his terms, from his adopting the old scholastic words and phrases with a new meaning, and employing the same word in different senses. His rich, prophetic imagination led him to the use of a lofty and poetic diction, which, though it may not altogether approve itself to a severe and philosophical criticism, often clothes his conceptions with singular beauty, embodies them to the imagination in forms of commanding energy, and impresses them deeply on the mind. His latinity in the *Novum Organon* is not to be despised; though he necessarily uses words and adopts meanings which are not to be found in the authors of classical antiquity: the subject on which he writes was new to the learned world, and he was evidently more solicitous to make himself understood, than to attain to the Augustan purity of the Roman idiom, or discourse in the music of its cadences, as we find them in Cicero's philosophical writings.

In closing this Treatise we may safely affirm, that, by giving the Inductive Philosophy to the world, Lord Bacon has proved one of its most signal benefactors; and has largely done his part towards promoting the final triumph of all truth, whether natural, or moral and intellectual, over all error; and towards bringing on that glorious crisis, destined, we doubt not, one day to arrive, when, according to the allegorical representation of that great poet who was not only the admirer of Bacon, but in some respect his kindred genius—TRUTH, though "hewn, like the mangled body of Osiris, into a thousand pieces, and scattered to the four winds, shall be gathered limb to limb, and moulded, with every joint and member, into an immortal feature of loveliness and perfection."







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